DOMINICANS, DECOMPRESSION AND DOPING: THREE ESSAYS ON THE ECONOMICS OF SPORTS

by

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ABSTRACT

Chapter 3 uses panel data of performance statistics, salary and birth place from 1990 – 2008 to assess the return to team investment in undrafted Major League Baseball players. The study finds that over the first 3 years and over the first 6 years, undrafted players produce larger returns to investment than do drafted players over these time periods while international free agents produce smaller returns to investment than do drafted players. The impact of a reverse order international player draft is discussed in light of these findings.

Chapter 4 develops a new measure of competitive balance that builds on the traditional binomial competitive balance ratio, R measure by incorporating end of season point outcomes in which games within the season meaningfully have ended in a draw. The measure is used to measure league parity in the professional sports leagues, the National Hockey League (NHL) the Russian Elite League (REL) and the Czech Republic League (CRL). Granger causality is then used to test the effects of an increase in the size of the labor pool in the NHL, due to the movement of players to the NHL from the REL and CRL. The corresponding effects on competitive balance of a decrease in the size of the labor pool in the REL and CRL are tested for as well.

Chapter 5 generalizes the simple Performance Enhancing Drug Game to include the scenario in which a player receives a payout through the disqualification of the other player. The game is then generalized further to a four-person tournament to determine if there is more or less incentive to use performance enhancing drugs. Using examples from the 2009 US Open Tennis Tournament and the 1999 Winston Cup NASCAR Series, this study finds that relative to a single one-off game the tournament format creates less disincentive for athletes to use Performance Enhancing drugs and that a more equal distribution of prizes deters Performance Enhancing drug use among athletes.

Thanks mom, dad and Colour for all your help and encouragement. I could not have done this without you.

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CHAPTER 1

INTRODUCTION

When John Rawls formulated his general conception of justice by noting that “All social values - liberty and opportunity, income and wealth, and the basis of self respect – are to be distributed equally unless an unequal distribution of any, or all, of these values is to everyone’s advantage” (Rawls, 1971, p. 62) he was probably considering more weighty issues than North American Professional Sports Leagues. But sports like life is often a game of chance in which “nature deals out attributes and social positions in a random or accidental way” (Rawls, 1971, p. 15). It is the element of chance which draws fans to sporting events. If the outcome of the game were certain then one would expect fewer fans in the bleachers and it is in the interest of professional teams that rely on this fan interest for revenue, to ensure that the outcome of the game maintains some element of chance. A league which depends on the interest of its fans will endeavor to construct a set of rules, something like a social contract, which maximizes fan interest. In this contract we might imagine a stipulation which inhibits teams with a large revenue base, due to geographic location, from paying incoming players a salary which exceeds the amount a smaller revenue team could pay. A restriction placed on incoming players would be such a stipulation. The reverse order draft in Major League Baseball (MLB) stipulates that the team which ends the season with the worst record is allowed the first pick of incoming players the following season. This sort of policy attempts to prevent high revenue teams from purchasing the contracts of the best incoming players thereby making them even more certain to win. One might say that a reverse order draft is an attempt to maximize the talent of the team with the minimum amount of talent, a policy John Rawls might agree with. An international reverse order player draft is consistent with a fair league policy in that it is directed toward reducing the impact of a team's ability to win as the result of income inequality.

When a player enters MLB they are subject to the reserve clause. The reserve clause is the result of what has come to be known as the Federal Baseball decision of 1922 (Federal Baseball Club of Baltimore v. National League of Professional Baseball, 1922). The upstart Federal League sued the National League for the right to sign National League baseball players arguing that the reserve clause was a violation of the Sherman Act of 1890. The case went before the Supreme Court and Justice Oliver Wendell Holmes ruled against the Federal League noting that the reserve clause was not a violation of interstate trade.[1] The reserve clause from the 1920s to the 1950s read as:

> [I]f, prior to March 1, … the player and the club have not agreed upon the terms of such contract [for the next playing season], then on or before ten days after said March 1, the club shall have the right to renew this contract for the period of one year on the same terms, except the amount payable to the player shall be such as the club shall fix in said notice…. (Quirk & Fort, 1997, p. 185)

The reserve clause allowed team owners to extend a player's contract at the stated price every year. The reserve clause was challenged by the St. Louis Cardinal Curt Flood when the Cardinals traded him to the Philadelphia Phillies at the end of the 1969 season.

[1] For an in depth discussion of the history of the reserve clause in MLB and other North American sports leagues see Quirk and Fort (1997) or for MLB specifically see Bumgardner (2000).

Flood, along with the Major League Baseball Player's Union, sued the commissioner's office for free agency and $3 million[2] Flood lost the case and what was left of his career. It was not until Jim 'Catfish' Hunter, with the help of arbitrator Peter Seitz, argued that the Oakland A's owner, Charley O'Finley had violated a clause in Hunter's contract in regard to his retirement fund. In 1975, Hunter went from the A's to the Yankees to become MLB's first free agent and also the first player to sign a $1 million contract. At the close of the 1976 season 25 major and minor league players became free agents marking 1976 as the first significant year of free agency in MLB (Sommers & Quinton, 1982).

The restriction on the competitive bidding process has had, in addition to possibly improving parity between teams, the effect of reducing the salary of potential draftees[3] by limiting the ability of high revenue teams to bid up the price of the player's contract. History has shown that when teams have the ability to freely compete against one another player salaries do increase. For example when the reserve clause was abolished in 1976 and players with 6 years of MLB experience were allowed to become unrestricted free agents, player salaries in increased by 38% in 1976 and continued to grow at a rate of 17.8% per year following 1976 when prior to 1976 the per year growth rate was only 1.6% (Fort, 2006). The dramatic increase in player salaries when teams are allowed to competitively bid for the rights to employ the player leads one to question the efficiency of the labor market for professional baseball players. If players are paid their marginal

[2] For a discussion of the case see (Leeds & von Allmen, 2008, p. 131).

[3] Rick Monday, who was the first overall selection in MLB's 1965 inaugural draft, received a signing bonus of $104,000 while Rick Reichardt received $250,000 in the year prior. In recent years these numbers have been climbing. Burger and Walters (2009) report that the total bonuses for the 30 first round picks in 2007 was US $62.9 million.

revenue product when their contracts are restricted then when they become free agents and their salaries increase they must be being overpaid while if they are not overpaid as free agents then they must be exploited as restricted players.

With the recent influx of players from countries not subject to the draft (see Figure 1.1), the issue of extending the draft one step further to include international players presently not subject to the draft is receiving some notice. MLB's *The Report of the Independent Members of the Commissioner's Blue Ribbon Panel on Baseball Economics* (2000) lists an international draft as one of its five recommendations for Rule 4 draft reforms noting that, "the implementation of a worldwide draft would ensure all clubs, regardless of revenue, relatively equal access to the crucial foreign player market" (Levin, Mitchell, Volcker & Will, 2000, p. 141). The Blue Ribbon Panel Report explicitly states a Rawlsian position, in that regulation over incoming foreign born players is meant to reduce any disadvantage a small market, low revenue team would have in the MLB labor market.

The worldwide draft would undoubtedly provide relatively equal access to the foreign player market but would this benefit small market clubs or reduce the disadvantages associated with being a small market club, namely that a small market club has to pay lower salaries to remain profitable? Some have argued that the draft has the unintended consequence in that it creates a mechanism through which perennial losers, who might also be low revenue teams, act as training centers for higher revenue teams. The losing team drafts the player and pays for training and developing the player and then when the player becomes eligible for unrestricted free agency they are unable to sign

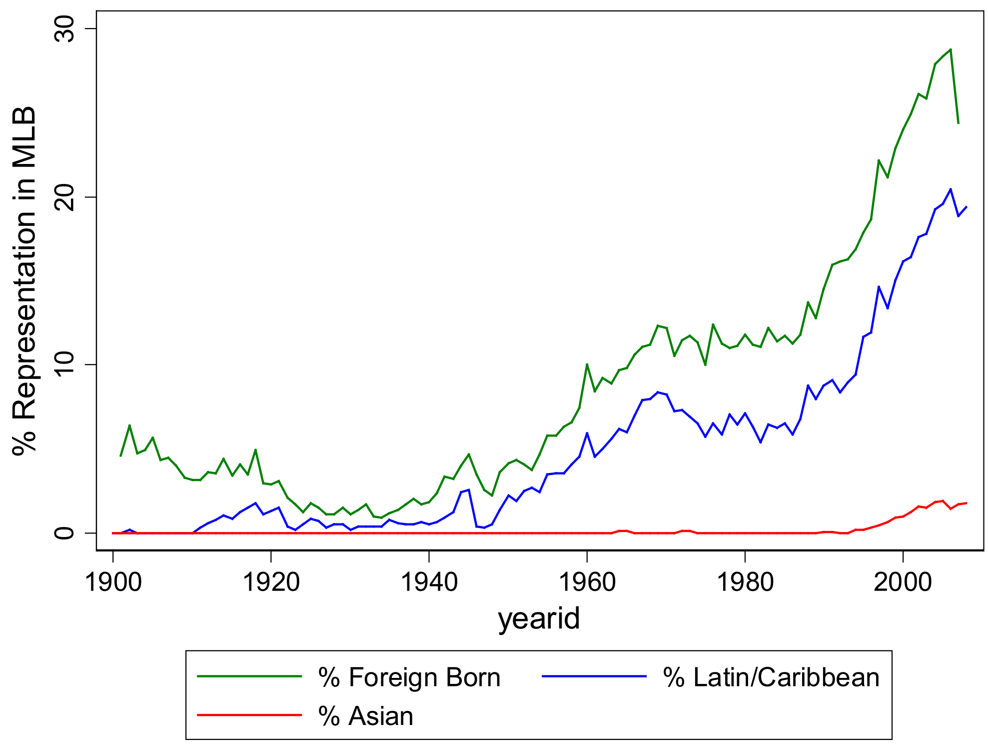

Figure 1.1: The percentage of players born outside the US, Canada or Puerto Rico playing in MLB.

the player since they cannot match the bid of the large market team. This would only be a negative result for the small market team if they were not receiving a return, as marginal revenue, to their investment in the player's salary. If the perennial loser, who also perennially drafts high, gets a return in the form of marginal revenue product from the drafted and reserved player above what they are paying the player then the draft could have the effect of reducing the small market disadvantage.

The international player not being subject to the draft enters the league as a free agent, with the only requirement that he be 16 years old. These so called amateur free agents could provide teams, small or large, with a cost effective means of acquiring young talented players. Alan Klein argues this point:

> For what a top college draft choice would cost in the United States (approximately $500,000 [late 1980s]), one could sign 100 Dominican prospects and be reasonably assured that a half dozen would become Major Leaguers. (Klein, 2006, p. 124)

A reverse order draft would eliminate this 'brute force' method of acquiring international players and could reduce the amateur free agent advantage to the small market team. On the other hand, the competitive bidding process for incoming free agents could drive the salaries of the players above that of their marginal revenue products, resulting in what is often called the "winner's curse." A "winner's curse" occurs in sealed bid auctions, like the free agent market, due to the expected value of what is being bid on being equal to the average of all the bids, but the winning bidder is the firm/team that bids the most, which will be above the average, thereby cursing the overpaying winner. All profit maximizing teams can ill afford to overpay players, but it seems reasonable to assume that teams with smaller revenues could also have smaller profit margins and could then be harmed by an overpayment more than teams with larger revenues.

An example might be useful here. Forbes magazine reports that the New York Yankees' total revenue for 2010 was $441 million while the Florida Marlins total revenue stood at $144 million. Suppose the New York Yankees and Florida Marlins were bidding for a player's contract and that the winning bid for the contract is $10 million. Further suppose that there is a curse attached to this player, such that his marginal revenue product (MRP) will be less than his contract. Let's say that if the Yankees won the contract then the player would produce $8 million in marginal revenue while if the Marlins won the contract the players MRP would be $5 million, due to the lower revenue potential of the Marlins. Both teams would be overpaying, but the Yankees would be overpaying $3 million less than the Marlins. In addition, the impact of the overpayment is compounded by the Marlins' lower total revenue. As a percentage of total revenue the Yankees would only be overpaying 0.5% (0.5 = $2/$441 x 100) of their total revenue and the Marlins would be overpaying 3.5% (3.5 = $5/$144 x 100) of their total revenue. If the amateur free agent market was cursing winners then a draft could work toward reducing the disadvantage a small market team has in a competitive labor market by reducing the impact of the "winner's curse."

An international reverse order player draft is consistent with a fair league policy in that it is directed toward reducing the impact of a team's ability to win as the result of income inequality. The research question addressed in Chapter 3 asks would a reverse order international draft provide teams with a larger return to investment than competing on the amateur free agent market. More explicitly, do amateur free agents receive a larger or smaller percentage of their marginal revenue products than do drafted players?

Unlike in MLB, the National Hockey League (NHL) applies the reverse order draft to International players entering the league, but what happens when the talent supply from which this draft selects from increases? During the first round of the NHL draft, NHL teams select the 30 best incoming players. One could suppose these players are ranked in descending order of talent where the first player selected is the most talented the 2nd player selected is less talented than the 1st but more talented than the 3rd and so on until the 30th player. If the talent pool increases from one year to the next then it could be the case that there are, say 32 players talented enough to go in the first round, but since only 30 can be selected what would have been the 29th and 30th players selected moves to the 31st and 32nd position. The top 30 players would now be collectively more talented than the top 30 players from the year prior.

How many fewer Stanley Cups would the Montreal Canadiens have won[4] if there were enough players to construct an opposing team just as talented as those early Montreal teams? Andrew Zimbalist (1992, 2003, 2006) refers to the situation where there are more players chasing the same number of roster spots as talent compression in that the larger number of high talent players are being compressed into the same number of roster spots (i.e., the proportion of roster spots to population decreases, becomes compressed). Talent decompression is the situation where the league expands the number of teams and the size of the talent pool remains relatively constant such that there are more roster spots with the same size population (i.e., the proportion of roster spots to population increases, becomes decompressed). The idea of talent compression and

[4] The Montreal Canadiens have won the most Stanley Cup championships with 23, the last being in 1993. The Toronto Maple Leafs are a distant second with 11, the last being 1967.

decompression is similar to what has come to be known as the "Gould Hypothesis" after a 1983 *Vanity Fair* article by the evolutionary biologist Stephen J. Gould which argues that as the talent in a sports league becomes more compressed, variation in the skill level of the players will decline and parity in the league would improve. Gould's idea is taken from patterns of evolution. Leaving aside for a moment revenue and salary differentials we could assume that, if given a choice between a more talented player and a less talented player, a team would naturally select the player who is more talented. Gould was looking at why nobody has hit for a .400 batting average since Ted Williams did it in 1941. Gould's hypothesis was that as the league expanded the size of its talent pool, through integration and global labor markets, high talent hitters were facing high talent pitchers more often and thus less likely to get a hit 40% of the time. J. C. Bradbury frames Gould's point.

> As the overall quality of players improves, extreme achievements should decline. Adding or subtracting players affects the distribution of talent in the league by including or excluding marginal major league players. (Bradbury, 2007, p. 96)

When a league expands the size of the talent pool, talent in the league becomes more compressed and as talent becomes more compressed extreme achievements should decline. Extreme achievements can be at the level of the player, no season long .400 averages in baseball since 1941, no season long triple double averages[5] in basketball since the 1961-62 season. Extreme achievements can also be at the team level. The most points in an NHL season was achieved in the 1976-77 season by the Montreal Canadiens who outscored their opponents by an average of 2.7 goals a game while the 1974-75

[5] In the 1961-62 season Oscar Robertson averaged 30.8 points, 12.5 rebounds and 11.4 assists per game.

Washington Capitals managed the fewest points ever in an NHL season with 21. One could imagine that the outcome of game between the 1976-77 Canadiens and the 1974-75 Capitals would be far from uncertain. We could hypothesize that as talent becomes more compressed the uncertainty of outcome increases.

On the other hand, talent decompression works in the other direction, again J. C. Bradbury, “Theoretically, when MLB expands its size the league becomes worse in absolute terms, because those who were previously not deemed worthy to play in MLB become members of new MLB teams” (Bradbury, 2007, p. 97).

When a league expands the number of teams, talent becomes decompressed. Rodney Fort (2006) notes that in Major League Baseball, it takes on average 7.2 years for an expansion team to achieve a .500 winning percentage (Fort, 2006, p. 142). Since baseball, like most other sports, is a zero sum game, the first 7 years after an expansion would be a period where there were more teams with above .500 winning percentages and more teams with below .500 winning percentages than in prior years. This could lead to the hypothesis that as talent becomes decompressed the inequality of the distribution of winning percentages would increase.

Professional ice hockey provides an interesting natural experiment to test the “Gould hypothesis.” The recent influx of skaters born outside Canada or the US (Figure 1.2) provides a case of talent compression in the NHL from which can be assessed the impact of the talent supply on league parity. The rival World Hockey Association (WHA), in existence from 1972 to 1977, and the increased number of teams from 6 teams prior to the 1966-67 season to 30 teams by the 2000-01 season provide a case of talent decompression.

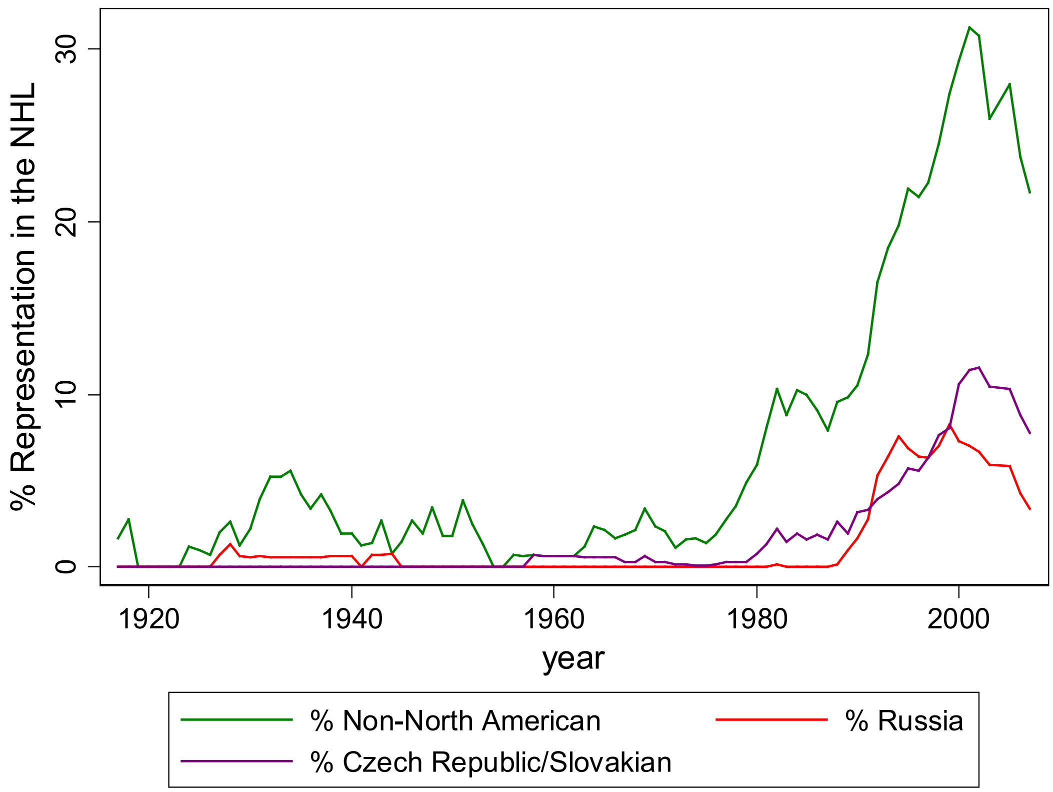

Figure 1.2: Percentage of Non-North American, Russian and Czechoslovakian players in the NHL.

Looking at Figure 1.2 it can be seen that the majority of the new NHL talent pool comes from Russia after 1989 and the Czech Republic in the early 1980s. If it is assumed that the most talented Russian and Czech players choose to go to the NHL then the leagues from which these players would have played, the Russian Elite League (REL) and the Czech Republic League (CRL), are experiencing the opposite situation to that of the NHL, namely a situation in which there are fewer players chasing the same number of roster spots. If the "Gould hypothesis" holds, we should see an increase in league parity in the NHL as the talent pool expanded in the 1980s and we should see a decrease in league parity in the REL and CRL as skaters moved out of these leagues to the NHL. Chapter 4 explores talent compression and decompression in 3 professional hockey leagues, the National Hockey League (NHL), the Russian Elite League (REL) and the Czech Republic League (CRL). The underlying hypothesis is that an increase in the size of the talent pool will, through profit maximizing teams wishing to find the most talented players, more equitably distribute wins in professional sports leagues.

If the talent of the players on a given team determines the number of wins, losses or draws that team achieves then a measure of competitive balance which measures the distribution of end of season point totals will be related to the distribution of talent in the league (Zimbalist, 2003, 2006; Schmidt, 2006; Schmidt & Berri, 2003, 2005). The notion of the uncertainty of outcome is closely related to the notion that at the outset of any game either team has an equal chance to win, or that each team has a fair chance of winning any game. A league wishing to maintain fairness in the distribution of wins would want a contract which does in fact promote an equal distribution of wins, which begs the question, what is an equal distribution of wins when there is some degree of chance in the outcome of any game? Chapter 4 develops a measure to address the degree to which wins are distributed in a sports league which includes the possible outcome of a tie game given the natural affect of chance. Chapter 4 goes on to use this measure to test how an increase in the size of the talent pool impacts the distribution of wins.

Finally, the notion of fair play, which we could assume affects uncertainty of outcome, comes down to fair play between the players on the field, the ice or the court. A just social contract would strive toward eliminating any means a player could potentially employ which would provide them with what is seen as an unfair advantage on the field, the ice or the court. The rules of play on the field are intended to establish a level playing field on which player actions which are seen as unsportsmanlike or unfair are penalized. A fair league would want to ensure that the games themselves be fair in that no team or player is disadvantaged at the outset. A fair league could reduce disadvantages through establishing a system of rules which prohibit athlete actions which lead one athlete or team to be unfairly advantaged. For example, Floyd Landis had his 2006 Tour de France titled stripped from him and was suspended from professional cycling for 2 years when it was found that he used synthetic testosterone during a stage providing him with an unfair advantage over the other riders.

The first ban on performance enhancing drugs (PEDs) came in 1928 when the International Amateur Athletic Federation banned “stimulating substances” (Savalescu, Foddy & Clayton, 2004). Hartgens and Kuipers (2004) demonstrate that the anabolic steroid androgen could increase muscular strength by 5%-20%. Certain drugs are now banned in almost all organized sports. The World Antidoping Agency (WADA) characterizes this as prohibited substances and prohibited methods:

(i) Prohibited substances: stimulants; narcotics; anabolic agents; diuretics; peptide hormones; mimetics and analogues; agents with antioestrogenic activity; masking agents.
(ii) prohibited methods: enhancement of oxygen transfer; pharmacological, chemical and physical manipulation; gene doping.
(Preston & Syzmanski, 2003, p. 615)

The reasons for the ban are summed up by Preston and Syzmanski (2003):

(i) it damages the health of athletes;
(ii) it gives doped athletes an unfair advantage;
(iii) it undermines interest in the sport;
(iv) it undermines the reputation of sport.
(Preston & Syzmanski, 2003, p. 616)

Statement (ii) directly imports the Rawlsian sense of fairness noted at the outset and statements (iii) and (iv) follow from (ii), so it appears that antiPED policy is to some degree modeled on a Rawlsian just social contract. It is in the interest of a profit maximizing organizing body to keep fans interested in any particular sport and if it is assumed that fans consider PED use to be an unfair advantage and fans dislike an unfair advantage (i.e., if fans behave as if they are considering a Rawlsian social contract) then it would follow that an organizing body would try to implement policy that establishes disincentives for PED use in sport. But how does a league go about implementing a policy which effectively and fairly eliminates PED use? Should PEDs be just like any other rule violation in sports?

If a baseball player charges the mound to fight the opposing pitcher the player is ejected from the game. If there was not a penalty for this then we might expect that the Yankees would go ahead and sign Mike Tyson to a multiyear deal so he could charge the mound every other game. If a player is caught using performance enhancing drugs in MLB he is suspended for 50 games without pay resulting in a potentially very large fine for the athlete. For example, Manny Ramirez was suspended for 50 games for using a banned substance. The fine effectively cost Manny $6.9 million dollars in lost salary. Is this a fair punishment? Chapter 5 addresses this issue by looking at the incentives which would lead the rational athlete to deviate from the fair social contract by using performance enhancing drugs to obtain an unfair advantage. Modeling an athlete's decision to use banned performance enhancing drugs as a four-player, two-stage tournament style game this chapter attempts to determine what would be a fair policy to deter performance enhancing drug use in sporting competition.

In addition to constructing contracts to promote fair play and the fair distribution of talent, sport organizing bodies have to construct a prize format which induces effort from the competing athletes. In sporting events such as running, golf, tennis, swimming or car racing, where relative effort is the determining factor in final placing, the organizing body has to provide a prize structure which elicits maximum effort from the athletes involved. If all the runners in the 100-meter dash choose to walk then the winner could win with a time of 50 seconds or more. A Rawlsian sense of fairness would suggest that an athlete receive a reward equal in value to the effort employed by the athlete to obtain the reward but if all athletes collude and decide to each give little effort then the reward provided is unfair to the fans who are disadvantaged in that they are not the ones on the track or the court. The organizing body has to establish a reward scheme which maximizes effort of the athlete to be fair to the fans but if that reward scheme is too unbalanced, in that the winner receives too large a reward, the athlete might try to elude organizers and cheat. Chapter 5 looks at fairness on the court as concerns performance enhancing drug use by athletes. In this chapter a game theoretic interpretation of an athlete's decision to violate league policy and use banned performance enhancing drugs is employed to determine what would be a fair deterrent mechanism for sport organizing bodies wishing to deter athletes from violating league policy.

Chapter 2 reviews the literature on the "winner's curse," competitive balance, tournaments as optimal contracts and performance enhancing drugs in sports. Chapter 3 addresses the return to investment in professional baseball players in MLB. Chapter 4 develops a trinomial measure of competitive balance and tests the "Gould hypothesis" in the NHL, REL and CRL. Chapter 5 constructs a multistage tournament game and discusses the effect on athlete incentives of differing reward schemes and penalties. Chapter 6 concludes.

CHAPTER 2

LITERATURE REVIEW

2.1 Player MRP and the Bidding Process

The notion that the winner in a bidding process can be cursed by over estimating the value of the item being bid on began[1] with Capen, Clapp and Campbell (1971). The engineers were looking at prices of drilling rights for land. They found that when oil leases were federally auctioned, the bids tended to be higher than the returns. "Unexpectedly low rates of return, however, follow the industry into competitive lease sale environments year after year" (Capen, Clapp & Campbell, 1971, p. 651). If it is assumed that the auction is a common value auction, such that each bidder values the drilling rights equally and if it is assumed that the bids are unbiased so that "the mean of the estimates is equal to the common value of the tract" (Thaler, 1988, p. 192), then the winning bidder will have bid higher than the common value of the tract, since in order to win the auction the winning bid had to be the largest. In an early piece of experimental economics, Bazerman and Samuelson (1983) ask 419 MBA students in 12 microeconomics classes to bid on the a jar full of $8.00 worth of coins or paper clips (each paper clip had an established value of 2 cents or 4 cents depending on size). The subjects did not know the actual value of the jar of coins. The students were told that the

[1] Thaler (1988) explicitly gives credit to this as the origin.

highest bidder would receive the value of the jar in exchange for paying her bid. The mean winning bid for 48 auctions was $10.01 or $2.00 more than the actual value of the jar. The authors argue that "in an auction setting, two factors are shown to affect the incidence and magnitude of the "winner's curse:" (1) the degree of uncertainty concerning the value of the item up for bid and (2) the number of competing bidders" (Bazerman & Samuelson, 1983, p. 618).

These two early papers spawned two lines of literature in regard to the "winner's curse." One line looked to the field for examples of a "winner's curse" while the other turned to the laboratory. Research from the field tends to support the existence of a "winner's curse" in a variety of auctions. Roll (1986) looks at the market for corporate takeovers and the purported shareholder gains from corporate takeovers and forms what he calls the "hubris hypothesis" which is that hubris drives bidding firms to pay too much for the target. In other words, hubris causes firms to not recognize the "winner's curse" inherent in auctions and adjust their bids downward. Varaiya (1988) finds empirical verification of Roll's hypothesis. In this study, 67% of the time winning bids exceeded the market's estimate of the gains from taking over the firm. Koh and Walter (1989) and Levis (1988) find that in the market for initial public offerings of common stock (IPO) investors do manage to lower the bids to compensate for a potential "winner's curse."

If the potential for a "winner's curse" is known by the bidders to exist, then the rational bidder should reduce her bid to compensate for the potential curse by bidding less. Thiel (1988) shows that at least in the case of the highway construction industry, this is the case. Hendricks and Porter (1988) found an effect of private information in the case of drainage leases.[2] They found that firms that were geographically closer to the tract of land being bid on (what they call "neighbor" firms) better assessed the value of the land and won the majority of the profitable drainage tracts, while firms that were geographically further away ("nonneighbor") firms earned zero profits. This study highlights the relationship between a "winner's curse" and asymmetric information, presuming that the neighbor firms might have had some bit of private information relevant to their bid which better allowed them to better assess the value of the lease.

Kagel and Levin (1986) constructed an experiment with multiple auction periods with the same bidders, so that over multiple auction periods the bidders had some experience with the experimental procedure. Subjects were given starting balances in which profits and losses were added over multiple rounds. If a subject's balance went negative then the subject was not allowed to continue bidding. Balances were set such that subjects were allowed to commit at least one large bidding error and still have the ability to participate in the following auction. After each auction, bidders were given information as to the winning bid, all other bids and the true value of the item being bid on. Thus, over the course of the multiple auctions, bidders could learn about the actual earnings of the winning bidder as well as acquire experience as to the relationship of their bids to the true value of the item. The results of the experiment are interesting in that in groups of three or four bidders, profits were generally positive while in larger groups of six or seven profits were negative. A "winner's curse" then seems to be to some degree dependant on the number of bidders.

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[2] A drainage sale "consists of the simultaneous auction of tracts which are adjacent to tracts on which deposits have been discovered" (Hendricks and Porter, 1988, p. 865).

One might argue, as Dyer, Kagel and Levin (1989) do, the students participating in the study are not experienced enough in the finer points of the auction process and as such are simply committing errors due to naiveté. The authors look at the construction contract industry and separate the subjects into two groups, “experienced” and “naïve.” The “experienced” had “real world” experience bidding for contracts in the industry while the “naïve” subjects were college undergraduate students with no “real world” experience. The authors found evidence consistent with a “winner’s curse” phenomenon in both groups.

Other experimental studies (Lind & Plott, 1991; Kagel & Levin, 1991; Kagel & Richard, 2001; Kagel & Levin, 1999) focusing on experienced versus inexperienced bidders continually find a “winner’s curse” with both experienced and inexperienced bidders in that experienced bidders “persistently earn only about half the profits predicted under the symmetric, risk neutral Nash equilibrium” (Kagel & Richards, 2001, p. 416).

Professional sports provide an interesting natural experiment to test the existence of a “winner’s curse” in auction markets in that the study of sports markets can marry the reality of the field studies with, to some degree, the control of experimental studies. Unlike class room experiments using rather small sums of money and relatively inexperienced subjects, professional sports leagues and the decision to employ players involve large sums of money and is (although some may disagree) the arena of experts in evaluation. In addition the availability of data and focused nature of production (i.e., player’s produce readily observable wins or losses) allow for the researcher to have access to the relevant variables.

The analysis of a "winner's curse" phenomenon requires two values: (1) the actual value of the item and (2) the estimated value of the item equal to the bid offered. For example, in the case of oil tract leases, these values are the return derived from the oil extracted from the tract of land and the price paid for the right (the lease) to drill on the tract of land which should include the bidders expected profits from the land. If the returns are below the price paid then the purchaser of the lease will have overpaid for the land. If the overpayment is the result of a competitive bidding process then the overpayment is consistent with a "winner's curse." In the case of professional baseball players the two values are the marginal revenue product (MRP) of the player and the player's salary. If the player's salary exceeds his marginal revenue product then the player has been overpaid.

Any discussion of player marginal revenue product begins with Scully (1974). The Scully method estimates a player's MRP from (2.1.0), (2.1.1) and (2.1.2).

(2.1.0) $$TR_j = \alpha_0 + \alpha_1 X_j + \alpha_2 WPCT_j$$

(2.1.1) $$WPCT_j = \beta_0 + \beta_1 PERF_j$$

(2.1.2) $$PERF_j = f(PERF_{ij} Z_j) \text{ for all } i \text{ on team } j$$

where TR_j is the j^{th}'s team's total revenue, X_j is a vector of team specific factors affecting team revenue, $WPCT_j$ is the j^{th} team's winning percent, $PERF_j$ represents the j^{th} teams performance, $PERF_{ij}$ measures the i^{th} rostered players performance for team j, and Z_j is a vector of other inputs that could affect a team's performance.

The MRP of any team performance statistic, (slugging average, rebounds, goals, etc.) is then given by (2.1.4).

$$MRP_j = \left(\frac{\partial TR_j}{\partial WPCT_j}\right)\left(\frac{\partial WPCT_j}{\partial PERF_j}\right) = \alpha_2 \beta_1 \tag{2.1.4}$$

Scully estimated that a one-point increase in a team's winning percent raised total revenue by \$10,330 (i.e., α_2 = \$10,330) over the 1968 and 1969 seasons. He then estimated that a one-point increase in team slugging average improved a team's winning percent by .92 points (i.e., β_1 = .92).[3] Plugging these numbers into equation (2.1.4) for hitter's yields: $MRP_j = \$10{,}330 \times .92 = \$9{,}504$ per point of team slugging average.

The next step is to determine a player's marginal product (MP). Scully assumed that "individual performance carries with it no externalities, so that team performance is a linear summation of individual performance" (Scully, 1974, p. 921).[4] Scully used the

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[3] Scully's estimates for equations (1) and (2) are:

$$REVENUE_t = \underset{(-1.69)}{-1{,}735{,}890} + \underset{(6.64)}{10{,}330PCTWIN_t} + \underset{(4.61)}{494{,}585SMSA_{70}} + \underset{(4.28)}{521\,MARGA} + \underset{(1.84)}{580{,}913NL} - \underset{(-2.42)}{762{,}248STD_t} - \underset{(-3.13)}{58{,}523BBPCT_t}$$

$$PCTWIN_t = \underset{(.39)}{37.24} + \underset{(4.37)}{.92TSA_t} + \underset{(5.92)}{.90TSW_t} - \underset{(-4.03)}{38.57NL} + \underset{(3.77)}{43.78CONT_t} - \underset{(-6.17)}{75.64OUT_t}$$

[4] It should be noted that this move (assuming separability of player output) has come under some scrutiny from Zimbalist (1992) and Krautmann (1999). Both of these views argue against the separability of equation (3). For example, a player's slugging average will possibly be higher if he has a good hitter hitting behind him in that the pitcher is more apt to pitch strikes to him to try and strike him out as opposed to intentionally walking him because he thinks the next batter is an easier out. Zimbalist (1992) argues that a team's prior winning percentage should be incorporated into the analysis, since a player going to a winning team is more likely to be surrounded by good players, and

percentage of team output of performance to determine a player's level of contribution to the team. For offensive players he used the percentage of team at bats and for pitchers he used percentage of innings pitched. Resulting in (2.1.5).

$$MRP_{ij} = \left(\frac{ATBATS_{ij}}{ATBATS_j} \right) \left(PERF_{ij} \right) \left(MRP_j \right) \tag{2.1.5}$$

where MRP_{ij} is the marginal revenue product of the i^{th} player on team j, $ATBATS_{ij}$ is the number of plate appearances by player i on team j, $ATBATS_j$ is the total number of plate appearances by team j, and $PERF_{ij}$ is the slugging average of player i on team j. As an arbitrary example, Scully uses Hank Aaron in 1968 where Aaron accounted for 11% of team at bats and had a slugging average of 498, Scully estimated Aaron to be worth \$520,800 (=0.11 x 498 x \$9,504).

The Scully method has been used, in either its original form or a refined form, to test for market size affects, Sommers and Quinton (1982) and Burger and Walters (2003) find a positive affect of market size on marginal revenue. Burger and Walters find that the marginal revenue from a win is six times higher in large markets.

Cassing and Douglas (1980) were the first to test for the existence of a "winner's curse" in the market for free agent Major League Baseball players (MLB). Using the

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consequently the opposing team cannot construct a game plan around the player in question. Using this approach, Zimbalist determined that contrary to Scully's estimate of a 28% underpayment of MRP, free agents received a 23% overpayment. Krautmann (1999) looks at the salaries garnered by free agents and then uses this value to determine what players who have yet to become free agents should be paid. He concludes that players who have yet to achieve the 6 years required for free agency earn 25% of their MRP, 'journeyman' players (i.e., players who are eligible for free agency) receive a salary "that is essentially commensurate with his value" (Krautmann, 1999, p. 370).

methodology of Scully (1974) and estimating marginal revenue products of a group of 44 free agents in the years immediately following free agency (1976-1978), Cassing and Douglas (1988) found that 28 of the 44 free agents received $2.7 million more than their aggregate MRP. This equals a 20% overpayment which the authors conclude could not occur by chance. Kahn (1993) concludes that teams, wishing to avoid bidding wars and subsequent “winner’s curse” premiums sign players to long term contracts noting that, “The long term contract postpones (perhaps forever) the need to participate in the auction market” (Kahn, 1993, p. 163). Contrary to the views of Cassing and Douglas (1980) and Kahn (1993), Sommers and Quinton (1982), Raimondo (1983), and MacDonald and Reynolds (1994) all conclude that MLB free agent salaries are commensurate with their MRPs.

Burger and Walters (2007) look for a “winner’s curse” in the MLB free agent market updating the productivity of players by using a measure that measures the number of wins a player generates above a replacement caliber player (WARP).[5] The WARP measure includes both offensive and defensive player statistics and measures the marginal wins produced by the player in a given year. Building on the prior research of Burger and Walters (2003) and Solow and Krautmann (2007) which demonstrates a market size effect on player value (i.e., a win in a larger market is more valuable to the large market team than a win in a small market is to a small market team), the authors show that small market teams could be afflicted with a “winner’s curse” while large market teams have managed to avoid the curse. “In other words, there are signs that

[5] The WARP measure was developed by Baseball Prospectus. The authors use the third generation of WARP titled WARP3.

teams systematically failed to limit their bids to conform to free agents' diminished value in such markets [small markets]" (Burger & Walters, 2008, p. 117).

Eschker, Perez and Siegler (2004) test for the existence and persistence of a "winner's curse" for foreign born players in the National Basketball Association (NBA). Using player data from the 1996-97 season to the 2001-02 season and constructing an Ordinary Least Squares regression (OLS), truncated and a censored regression, the authors find that in the case of the truncated data set[6] foreign born players were paid 160% more in the 1996-97 season and 108% more in the 1997-98 season. This salary premium disappeared for the seasons 1998-99 to 2001-02 seasons prompting the authors to claim "The observed salary premium is consistent with a winner's curse…. However, once teams gained experience in evaluating the talent of these players and began to devoting more time and effort to scouting international talent, this winner's curse disappeared" (Eschker, Perez & Sigler, 2004, p. 1020).

Burger and Walters (2009) revisit the issue of the "winner's curse" looking at the rates of return for drafted player signing bonuses. The authors found systematic overpayment to high school players relative to collegians as well as overpayment of pitchers relative to position players. They also note that small market teams systematically fail to utilize their monopsony power to bid down bonuses commensurate with the players' lower expected MRP in a smaller market. Krautmann, von Allmen and Berri (2009) look at the impact of the reserve clause on player pay in the NFL, NBA and MLB finding that players under reserve in all three leagues experience some amount of underpayment due to the monopsony power of North American Sports Leagues.

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[6] The fact that the NBA has a minimum and maximum salary for players based on the number of years in the NBA suggests that the truncation of the data set is useful.

2.2 Global Labor Markets and Competitive Balance

> Competitive balance within a league is actually a catchall term that refers to a number of different aspects of competition on the playing field, but, in essence, there is more competitive balance within a league when there is more uncertainty of outcome in league games and pennant races. (Quirk & Fort, 1997, p. 244)

As noted earlier, fan demand and subsequently team profits are driven by the desire of the fans to see their favorite team win, but not be absolutely certain they will. Neale (1964) recognized this peculiarity of sports leagues early on when he noted that fan demand for sport increases the more equal in playing skill are the competitors (i.e., the more uncertain the outcome). Neale referred to this peculiar phenomenon in the sports economy as the "Louis-Schmelling Paradox".

> But now consider the position of the heavy weight champion of the world. He wants to earn more money, to maximize his profits. What does he need in order to do so? Obviously, a contender, and the stronger the contender the larger the profits from fighting him. And since doubt about the competition is what aroses interest, the demonstration effect will increase the incomes of lesser fighters… Pure monopoly is a disaster: Joe Louis would have had no one to fight and therefore no income. (Neale, 1964, p. 2)

This "paradox" not only points to the need for equal/fair competition, but also the lengths to which sporting organizations might have to go to achieve equal/fair competition. Certainly fan demand for the Louis - Schmeling fight had a lot to do with the fact that Max Schmeling was a German and Joe Louis was an African American and the fight was in 1936, but what the 12-round fight, in which Schmeling won, also showed was that if a fighter comparable[7] to Joe Louis could not be found in the American population then maybe one could be found if the boxing organization

[7] It took 12 rounds for Schmeling to knock out a rather disinterested Louis in the first fight while it took all of 1 round for a focused Louis to knock out Schmeling in the second fight.

expanded its search for talent overseas. Possibly to stimulate waning attendance levels, the National Hockey League decided to look for its own Schmeling.

The influx of foreign born MLB players has recently seen some interest by sports researchers. Osborne (2006) looks at skill specialization and country to find that Canada and Mexico produce more pitchers while Venezuelan and Puerto Rican players specialize in offense. Anderson and Andrew (2006) report on the general trends of more foreign born players in recent years. Schmidt (2006) and Schmidt and Berri (2005) look at competitive balance issues, finding that there has been an improvement in competitive balance associated with an increase in the size of the labor pool. Andrew Zimbalist (1992, 2003, 2006) refers to the situation where there are more players chasing the same number of roster spots as talent compression in that the larger number of high talent players are being compressed into the same number of roster spots (i.e., the proportion of roster spots to population decreases, compresses). Gould (1983, 1996) argues that as the talent in a sports league becomes more compressed, variation in the skill level of the players will decline and parity in the league would improve.

The "Gould hypothesis" has been tested on a few occasions since first being introduced. Chatterjee and Yilmaz (1991) use an entropy measure of the distribution of wins in MLB to find support for the "Gould hypothesis" in MLB. Schmidt and Berri (2003) use Granger causality tests concluding that competitive balance in MLB improved in the years following integration (1950 - 1984) and improved with the influx of foreign born players in MLB in the 1990s. Schmidt (2006) uses a nonlinear unit root test and finds that "the driving force in competitiveness has been the growing geographical diversity of Major League Baseball" (Schmidt, 2006, p. 10). Schmidt and Berri (2005) use unit root tests and the Herfindahl Herschman Index (HHI) on homeruns and strikeouts and conclude that the influx of foreign born players has been responsible for reduced variability in player performance. Not all tests of the "Gould hypothesis" have been positive though. Horowitz (2000) also uses an entropy based measure of variation and finds no evidence of shrinking variation in player performance. Hessenius (1999) standardizes batting averages over time and finds that the absence of a .400 hitter is not the result of talent compression and the subsequent improvement of the average hitter, as Gould suggested but rather that when an oscillating mean batting average is taken into account, .400 batting averages move in and out of a feasibly obtainable batting average.

Just as Scully (1974) is the starting point for marginal revenue product estimation, Rottenberg (1956) is the starting point for issues of competitive balance. Andrew Zimbalist notes that Rottenberg's article, "anticipated the Coase Theorem[8] in understanding talent distribution across teams and argued that the profit motive would limit the accumulation of player talent on any single team" (Zimbalist, 2002, p. 111). Rottenberg argues for what he calls the invariance principle which claims that the holder of the rights to a player's contract is irrelevant to the distribution of talent in a league. In other words, players will play for the team's that offer the most remuneration, whether the player receives the bulk of that remuneration or the team owner receives the bulk is irrelevant to for whom the player plays. In addition to driving average MLB player's salaries up by 39% from the 1976 to 1977 season (Fort, 2006, p. 267). Free agency

[8] This would be the 'theorem' attributed to Ronald Coase as the result of Coase (1960), which argues that if property rights are assigned to externalities such that they can be traded and there are no transaction costs, bargaining would lead to an efficient allocation of property rights regardless of the initial allocation of the rights.

provided researchers with a natural experiment to test Rottenberg's invariance principal, namely that free agency will not have an effect on the distribution of wins in sports league. Daly and Moor (1981), Fizel (1994), Fort and Quirk (1995), Lee and Fort (2005) and Scully (1989) find no significant effect of free agency and competitive balance in MLB. Depken (2002) finds that free agency has reduced the concentration of homeruns and Horowitz (1997) finds a general trend of improvement but most of the improvement comes after integration in 1947.

Rottenberg also developed the relationship between competitive balance and demand for sporting contests:

> If, it is argued, other things being equal, a team in an area with a large population has larger revenues than teams in less populous areas, then, in a free players' labor market, the former will get the most capable players, there will be wide variation among teams in the quality of play, contests will become certain, and attendance will decline. (Rottenberg, 1956, p. 247)

This passage makes two hypotheses: (1) teams located in more populated areas will have larger revenues and will use those revenues capably to obtain better players, subsequently winning more often and (2) fans prefer an uncertain outcome of a sporting contest to a certain outcome, what has come to be known as the uncertainty of outcome hypothesis (UOH). Hypothesis (1) underlies both the formal models of a professional sports leagues and empirical research into the relationship between revenues and winning. Hypothesis (2) is empirical and is most often measured using the relationship between competitive balance over time and attendance.

Assuming large market teams can and do pay more for talent and subsequently win more often (i.e., assuming hypothesis (1)), El-Hodiri and Quirk (1971) construct the first formal model of professional sports leagues, demonstrating that profit maximization is inconsistent with equalization of playing strengths and that the reserve clause will not have an effect on competitive balance. The theoretical models tend to focus on how league institutions such as revenue sharing, salary caps or free agency impact competitive balance and how different assumptions of the model affect these results.

El-Hodiri and Quirk (1974), Atkinson, Stanley and Tschirhart (1988), Marburger (1997) and Vrooman (1995) use a Nash equilibrium framework with a simplified two team league to demonstrate that in a league of profit maximizing owners, revenue sharing will not affect competitive balance. Rascher (1997) compares utility maximizing owners (i.e., assuming owners are maximizing wins) with profit maximizing owners and finds that revenue sharing will have a negative impact on competition if owners are maximizing utility while if they are maximizing profits, revenue sharing will have no impact.

Possibly as the result of the Bosman decision[9] of 1995, which opened international labor markets for professional European sports leagues, the nature of the talent supply of professional athletes has come into question, namely the conjecture[10] as to whether the talent supply is fixed or flexible (Vrooman, 2007).

El-Hodiri and Quirk (1971), Fort and Quirk (1995), Vrooman (1995) and Quirk and Fort (1997) assume that the talent supply is fixed so that if one team acquires a player and receives a talent gain then that gain is equivalent to a loss of the other team. This

[9] "In 1995, the European Court of Justice abolished not only the existing transfer system but also the so called 3+2 Rule, which limited the number of foreign players a club could field" (Kesenne, 2006, p. 418).

[10] A more formal discussion of the role conjectures play in theoretical models of sports leagues appears in Appendix A.

results in the conclusion consistent that revenue sharing will have no effect on competitive balance. Syzmanski and Kessene (2004) and Syzmanski (2004) allow for a flexible talent supply such that one team's talent decision has no effect on the other team's winning percent. The result is that revenue sharing has a negative impact on competitive balance.

Eckard (2006) argues that a fixed talent supply is more appropriate for professional sports leagues in that professional athletes earn so much money playing their sport that the next best alternative job would have a substantially lower salary, thus there is no incentive to move out of the market. These "quasi rents" should not have an impact on the quantity supplied. Eckard acknowledges that the quantity of talent changes over time (through minor leagues or training) but he argues that this is a long run phenomenon and at any one given time the quantity of talent in the league is fixed.

Kessene (2007) compares a flexible and fixed talent supply in a league with both profit and win maximizing owners. Kessene concludes that "for both the flexible and fixed talent supply, … competitive balance will be more unbalanced and that the market clearing salary level will be higher under win maximization than under profit maximization" (Kessene, 2007, p. 57). The question of win maximizing or profit maximizing owners is often drawn when comparing North American professional sports leagues and European soccer leagues. It is generally considered that owners of North American Professional sports teams have profitability as their objective while owners of European soccer teams quest for profits are often hindered by regulations (Zimbalist, 2003). Lago, Simmons and Syzmanski (2006) note that "in France, Spain and Germany, for example, the ability of clubs to operate as profit maximizing businesses has been limited by regulation or voluntarily, whereas in Italy and England, the scope for adopting commercial objectives has been greater" (Lago, Simmons & Szymanski, 2006, p. 5).

In regard to Rottenberg's second hypothesis, namely, fans prefer an uncertain outcome of a sporting contest to a certain outcome, sports economists have measured the uncertainty of outcome hypothesis using a variety of measures, the most common of which involves the standard deviation of winning percentages[11] first introduced by Noll (1988) and further developed by Scully (1989) and Fort and Quirk (1992, 1995). Maximum uncertainty occurs when each team is equally talented and as such the outcome of the game is a random variable. Fort and Quirk (1992, 1995) apply this methodology by looking at the distribution of wins in a sports league as measured by the standard deviation of end of season winning percentages, σ_{actual}. Due to the fact that different leagues play a different amount of games σ_{actual} needs to be adjusted if leagues and different time periods are to be compared. Fort and Quirk (1992, 1995) adjust the actual standard deviation of winning percentages with an idealized standard deviation intended to capture competition in a league of perfectly equal competitors. "That is, the idealized measure applies to a league in which, for each team, the probability of winning any game is one-half" (Fort and Quirk, 1997, p. 245). The idealized standard deviation is defined as, $\sigma_{ideal} = \frac{0.5}{\sqrt{games}}$. The actual standard deviation of winning percentages, σ_{actual} is then divided by the idealized standard deviation, σ_{ideal} to result in the measure of

[11] "The measure most commonly used by economists over the years has been something called "the standard deviation of winning percentages" (Szymanski & Zimbalist, 2006, p. 173).

competitive balance, R, where $R_t = \frac{\sigma_{actual}}{\sigma_{ideal}}$. As R moves toward unity from above the league is said to be more competitively balanced.

Scully (1989) uses the R in MLB to look into the effect of the end of the reserve clause and rejects the hypothesis that competitive balance is affected by free agency. Vrooman (1995) uses the *R* measure and concludes that free agency has not made balance worse in MLB and that the National Football League (NFL) is most balanced while the National Basketball Association (NBA) is the least balanced of the major North American leagues. Quirk and Fort (1997) use the *R* to test for free agency affects in the NBA, NFL, NHL and in MLB and conclude that there has not been a significant change before or after free agency for any league. Fort and Quirk (1995) use the *R* to conclude that free agency had no affect on competitive balance in MLB and there was no change with a salary cap in the NBA. They find some support that the rookie draft in the NFL improved competitive balance, but this was based on limited data (1930 – 1941). They find that there was improvement in balance as a result of the draft in MLB's National League but no improvement in the American League. Zimbalist (2003) uses the *R* to look at competitive balance in MLB over time, noting that it improved from 1965 to the 1980s but worsened after 1995. He lists five factors which he believes are responsible for the worsening of balance, "increased revenue inequality, more synergies from cross ownership, the inversion of the drafts leveling role, talent decompression with the addition of four teams, and the post 1996 revenue sharing system – combined in the 1990's to exacerbate baseball's competitive imbalance" (Zimbalist, 2003, p. 51).

Fort (2006) looks at the four major North American professional sports leagues (MLB, NBA, NFL and NHL). Competitive balance in the NBA has stayed constant and is the most unbalanced league. Competitive imbalance in the American League and National League has fallen by 13% and 42%, respectively, but has become worse in the 2000s (Fort, 2006). Competitive balance in the NFL has improved and Fort credits this to the fact that payrolls and revenues are relatively equal in the NFL. In the NHL Fort concludes that imbalance has worsened by 33% since its inception in 1918 but has improved since the 1970s noting that the 1970s produced the most unbalanced period in NHL history. Fort also looks at the R for the Big 10 and Pac 10 college football conferences. He finds no trend in competitive balance from 1970 to 2004, in that the decade averages are always above 1.5 and below 1.7.

Berri, Schmidt and Brook (2006) look at 15 different sports leagues including European soccer leagues and North American professional leagues in the big four sports. Over 644 league observations the average R was 1.86. The authors find that all the soccer and American football leagues had a lower R than 1.86.

Similar to the theoretical models of professional sports leagues, the empirical issues in competitive balance, noting a seeming lack of evidence that league institutions have an impact on competitive balance, seem to be turning toward the effects of how the talent supply impacts league competition. Schmidt and Berri (2003) use Granger causality tests concluding that competitive balance in MLB improved in the years following integration (1950 - 1984) and improved with the influx of foreign born players in MLB in the 1990's (using a data from 1911 – 1997). Schmidt and Berri (2005) use unit root tests and the Herfindahl - Herschman Index (HHI) on homeruns and strikeouts and conclude that the influx of foreign born players has been responsible for reduced variability in player performance. Schmidt (2006) uses the R to test for an increase in the size of the labor pool and the trend toward improving balance in MLB. Using a nonlinear unit root test he finds that “the driving force in competitiveness has been the growing geographical diversity of Major League Baseball” (Schmidt, 2006, p. 10).

While the Bosman decision of 1995 could provide a natural experiment for researchers addressing the issue of flexible talent supply and competitive balance empirically, the research in this area has been limited.[12] This could be due to the difficulty of measuring competitive balance in leagues which allow for a game to end in a tie (e.g., all European soccer leagues and the NHL prior to 2004). Some researchers have noted this difficulty, “[G]iven that the index [the R] has not been designed with drawn matches in mind, it is not the most appropriate index to measure competitive balance in football leagues were the number of wins per season varies” (Mitchie & Oughton, 2004, p. 7). The difficulty comes not with measuring the standard deviation of end of season point totals but rather with determining what an ideally balanced distribution of final season point totals would look like in a league that counts tie games toward this point total.

Cain and Haddock (2006) also note the difficulty with the traditional measure and address the difficulty by constructing an ideal standard deviation of final point totals that includes ties. Citing the fact that from the 1888-89 season until the 2003-04 season, Cain and Haddock calculate that wins occurred 37.705% of the time, loses 37.705% of the time and ties occurred 24.59% of the time in the English Premier League[13] and that the

[12]Other reviews of the literature on competitive balance, Zimbalist (2002), Fort (2006), Sanderson and Siegfried (2003), Sanderson (2002), Humphreys (2002), Fort and Maxcy (2003) and Kahane (2003) do not mention the Bosman decision and competitive balance.

[13] Prior to the 1992-93 season this league was known as the First Division.

distribution of game outcomes is similar for the Championship Division over the same time period. This distribution prompts them to calculate an ideal standard deviation of the distribution in which "teams entering a contest had, before the fact, a 25% probability of leaving with a draw" (Cain & Haddock, 2006, p. 332). Brandes and Franck (2007) use the Cain Haddock measure and Granger causality to test for a relationship between competitive balance and attendance for the major European professional soccer leagues, of Germany, England, Italy and France for the years 1963-63 to 2005-06. The authors find no link between competitive balance and attendance for these leagues.

2.3 The Performance Enhancing Drug Game

Lazear and Rosen (1981) introduced rank order tournament theory to provide a framework from which one can model compensation efficiency in markets where output is not easily measured. In such cases a rank order tournament will be a more efficient means of allocating compensation, "[I]f it is less costly to observe rank than an individual's output, then tournaments dominate piece rates and standards" (Lazear & Rosen, 1981, p. 848). Rosen (1986) extends the earlier work demonstrating that sequential tournaments a nonlinear reward scheme is most effective in producing maximum effort from the worker/athlete. Rosen (1986) notes that "the top four ranks receive 50 percent or more of the total purse in tennis tournaments" (Rosen, 1986, p. 701). He goes on to show that "an elimination design requires an extra reward for the overall winner to maintain performance incentives throughout the game" (Rosen, 1986, p. 701).

Figure 2.1 shows how a rank order reward scheme works. The marginal revenue is the reward to the athlete for moving up one level in the tournament, the marginal cost of effort is increasing as shown through the increasing slope of marginal cost curve and that as an athlete produces effort for a high place the marginal cost increases at a higher rate (i.e., is nonlinear). The firm or sporting organizing body then sets a prize structure similar to that in Figure 2.2 where the marginal prize declines more rapidly (i.e., prize structure is more nonlinear) or less rapidly (i.e., prize structure is less nonlinear). Sporting tournaments provide an ideal setting for testing the efficiency of rank order compensation schemes. Ehrenberg and Bognanno (1990) were the first theorists to empirically analyze rank order tournament theory in sports tournaments, using the 1987 European Men's Professional Golf Association they find that players "who faced larger marginal returns achiev[ed] better scores" (Ehrenberg & Bognanno, 1990, p. 86 – S). Lallemand, Plasman and Rycks (2008) find that larger prize differentials increase effort levels of professional women tennis players and that player abilities, as measured with apriori rankings are significant predictors of match outcome. Again using professional tennis matches, Sunde (2003) finds a significant effect of prizes on effort levels, where effort is measured as total number of games played. McFall, Knoeber and Thurman (2009) model a tournament with a grand prize (i.e., the winner of the majority of individual contests wins an additional grand prize) and find that in general and in the case of the Professional Golfers' Association Tour, the winner of early contests is more likely to continue winning throughout the middle stages of the tour. Using the total number von Allmen (2001) argues that a highly nonlinear reward scheme can create risk taking incentives for the athletes. He argues that the highly nonlinear reward scheme of golf

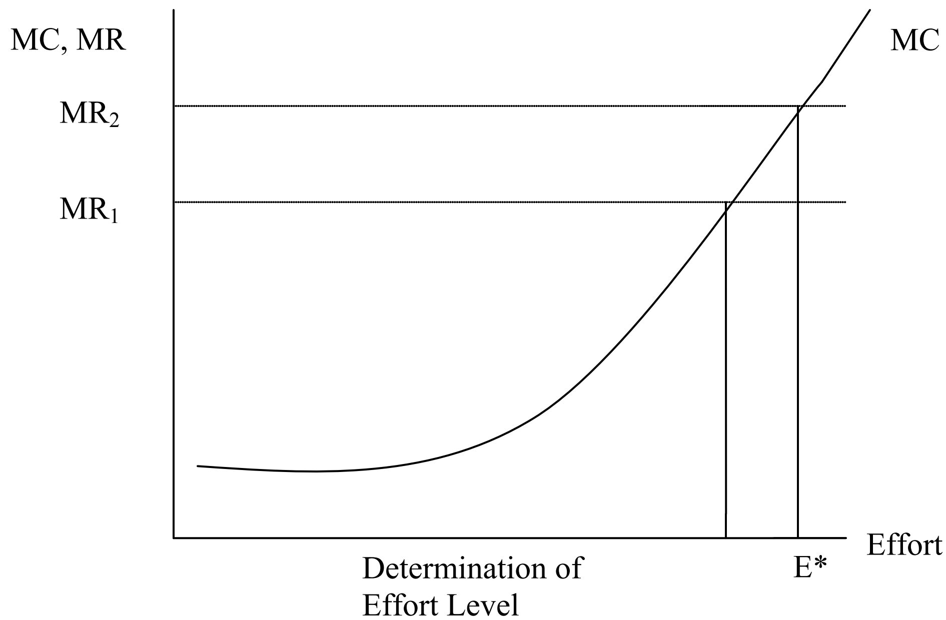

Figure 2.1: Optimal effort levels.

Notes: MR is the marginal revenue obtained from an additional unit of effort, and MC is the marginal cost of an additional unit of effort.

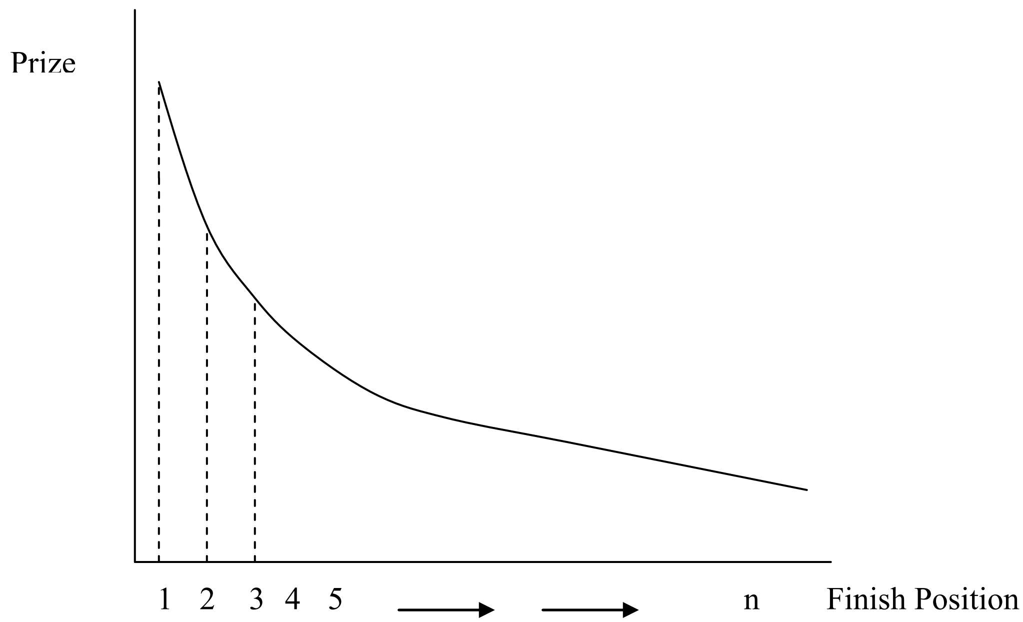

Figure 2.2: Prize and ranking.

relative to the more equal reward scheme of NASCAR is intended to reduce this risk taking incentive.

> If rewards are highly nonlinear, drivers have an increased incentive to exhibit reckless behavior. At speeds of 200 miles per hour, such behavior can have drastic consequences, not only for the driver that is struck but also for the perpetrator and other cars as well. (von Allmen, 2001, p. 76)

The relation of risk taking behavior and reward scheme can be carried over to the use of performance enhancing drugs (PEDs) by athletes competing to win in a tournament. Since in most professional sports PEDs are banned and if caught the athlete faces a costly penalty if caught the use of PEDs can be seen as risk seeking behavior. Furthermore, if the athlete's are equally skilled and already giving maximum effort, as we would expect at the professional level then variation in placing could be more attributable to luck rather than effort levels. For example, if two equally skilled athletes are competing in a one off game then they each have a 50% chance of winning, while if four equally skilled athletes are competing in an elimination tournament then their chances of winning drop to 25%. Equally skilled athletes can increase their chances of winning by doing something which the other athletes are not doing. This could be a different training regime or the more risky and unsportsmanlike behavior of cheating. Intuitively we can think of this as though all athletes are equally skilled and are giving as much effort as is humanly possible. If cheating will increase one athlete's chance of winning above that of pure chance then we would expect that athlete to cheat, but if the chance of that athlete being caught cheating and subsequently disqualified is larger than the improved chance of winning then we would expect the rational athlete to not cheat. In a multistage tournament relative to a single one off game the probability that a cheating athlete will be caught increases since she can be caught in any one of the rounds.

This leads one to suspect that a multistage elimination tournament like those found in tennis would provide a disincentive for cheating behavior. On the other hand, if rewards are highly nonlinear then the reward for first place as compared to fourth place might be enough to justify a rational athlete's incentive to cheat and thus a multistage tournament with highly nonlinear payouts would create an incentive to cheat.

The interaction of rewards, penalties and athletes' decisions makes the use of game theory a relevant tool for analyzing an athlete's decision procedure and what sort of mechanisms an organizing body that wishes to deter cheating might impose. Haugan (2004) focuses on the decision procedure of the athletes. Haugan (2004) models an athlete's decision to use performance enhancing drugs (PEDs) as a simultaneous one shot game. He finds that if both athletes are assumed to be of equal talent then the result of the game is a prisoner's dilemma game, but if it is assumed that the athlete's are not equally talented then a mixed strategy results. Eber (2008) maintains Haugan's initial assumption of equally talented athletes but adds fair play norms to the athletes utility functions such that a player receives some amount of disutility when they choose to use PEDs while the other chooses not to use the drugs, by adding fair play norms, the game is changed from a prisoner's dilemma to a stag hunt game with two pure strategy equilibria, pitting payoffs against risk. According to Bryan Skyrms (2001) the stag hunt was first told as a story in Rouseau's *A Discourse on Inequality*:

> If it was a matter of hunting a deer, everyone well realized that he must remain faithful to his post; but if a hare happened to pass within reach of one of them, we cannot doubt that he would have gone off in pursuit of it without scruple... (Skyrms, 2001, p. 1)

This story is an early example social contract theory. Two individuals go out on a hunt and can each individually choose to hunt a stag or a hare. Successfully hunting a stag requires cooperation of the two while hunting the hare does not. If both hunters can cooperate and hunt a stag then the payoff will be larger, but there is also more risk in that if one chooses to defect then the nondefector will get nothing. On the other hand, if both hunters choose to each hunt hare (no cooperation required) then the payoff will be lower but there is less risk involved, since they can both get something regardless of what the other does. Formally, it's a game with two pure strategy equilibria, one that is risk dominant (hunting hare) and one that is payoff dominant (hunting stag). In the PED game, the risk dominant strategy would be to dope with the equilibrium at doping and the payoff dominant strategy would be not dope with the equilibrium at not doping. Eber notes that "the main problem for the athletes becomes to coordinate their intentions and, hence, find a reliable coordinating device" (Eber, 2008, p. 319).

Following Becker (1968), Maennig (2002) models the use of banned PEDs in sports as a microeconomic model of illicit behavior. Maennig discusses a variety of policy measures in regard to deterring the use of PEDs such as externality effects and ad ministerial costs. Maennig concludes that, "An economic solution could increase the expected costs of doping by agreeing on financial penalties of a sufficiently high level" (Maenning, 2002, p. 83). The policy of increasing the costs to the athlete for being caught using PEDs will act as a deterrent, but if the testing procedures are not completely accurate it could also place an even larger unfair cost on a false positive. Berry (2008) notes that given the present state of the drug testing procedures in the Tour de France, there is between an 8% and 34% chance of a false positive; as such a Tour de France bike racer has between an 8% and 34% chance of being caught doping even if they are not doping.

2.4 Summary

In summary, the literature on the existence of a “winner’s curse” in the market for free agents is mixed. Cassing and Douglas (1980), Kahn (1993), and Burger and Walters (2007) find evidence consistent with a “winner’s curse” while Sommers and Quinton (1982), Raimondo (1983), and MacDonald and Reynolds (1994) do not find evidence indicating a “winner’s curse”. The most recent work of Burger and Walters (2007) utilizes the growing trend of foreign born players playing in North American professional sports leagues. The issue surrounding open labor markets has made its way into the competitive balance literature as well. Syzmanski and Kessene (2004), Syzmanski (2004) and Kessene (2007) incorporate a flexible talent supply into the theoretical models of professional sports leagues while Schmidt and Berri (2003, 2005) and Schmidt (2006 address global talent markets empirically. Finally, questions surrounding an athlete’s decision procedures are being explored in the work of Haugan (2004) and Eber (2008) while the reward schemes are first discussed in Lazear and Rosen (1981) and the efficacy of nonlinear rewards in sports is discussed in Von Allmen (2001).

CHAPTER 3

MORE BANG FOR YOUR BUCK: THE INTERNATIONAL DRAFT AND THE RETURN TO INVESTMENT ON INCOMING PLAYERS IN MAJOR LEAGUE BASEBALL

3.1 Introduction

In 1958 the New York Yankees offered a high school senior named Carl Yastremski $40,000 to bring his .650 batting to the Yankees roster, the Atlanta Braves countered with $60,000 while the Phillies raised that to $102,000. After a year in college Yastremski signed with the Red Sox for $108,000 and went on to hit 452 home runs and 3,419 Major League hits. Six years later in 1964, Gene Autry and his Los Angeles Angels offered an outfielder from the University of Wisconsin, Rick Reichardt, $250,000 to play for them. Major League Baseball's (MLB) old guard did not like the way things were going and instituted MLB's first reverse order draft for players entering the league in 1965. The Rule 4 draft allows the team with the worst record from the season prior to have the first choice in selecting a player coming into the league. The draft is intended to allow teams to move up into contention by restricting teams that presumably already have strong rosters from having first chance to sign incoming high talent players. By 1990 the Rule 4 draft had been extended to amateur players that are residents of the United States, Canada, Puerto Rico and other U.S. commonwealths, territories and possessions and mandates that "teams are not allowed to trade the rights to draft players" (Staudahar, Franklin & Lima, 2006, p. 29).

In this chapter I assess the issue of whether or not teams signing international players are receiving higher or lower returns to their investment. In other words, are the winners in the amateur free agent market cursed with overpaying for young talent and if so, does the reverse order draft act to reduce the overpayment? Section 1 develops a model of player MRP, Section 2 estimates the proportion of player MRP that the team receives in return for a one dollar investment in salary and Section 3 concludes.

3.2 Estimating Player MRP

Market size differentials have been at the center of sports economics since Simon Rottenberg published *The Baseball Players' Labor Market* in 1956. The argument as to the effect of market size[1] on the relative performance of teams on the field has essentially remained unchanged. Teams in larger markets have a larger demand than do teams in smaller markets. These demand differentials drive the marginal value of a win to a large market team above that of a small market team subsequently a players win producing ability will be more valuable for a larger market team.

Proceeding along the lines[2] of Scully 1974 I estimate a player's marginal revenue product with a three step process using pooled time series and cross sectional data from the 1990 to 2008 MLB seasons. Step 1 determines the value of team output with the

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[1] Market size is usually defined as population of the metropolitan area within which the team is located.

[2] See literature review for a detailed discussion of the Scully method.

dependent variable, the total revenue of team *i* in year *t* adjusted to 2008 dollars, summary statistics for (3.1.0) and (3.1.1) are reported in Table 3.1, results reported in Table 3.2.

(3.1.0) $$TR_{it} = \alpha_1 + \gamma_1 WPCT_{it} + \gamma_2 POP\_WPCT_{it} + \gamma_5 YEAR + \varepsilon_{it}$$

where $WPCT_{it}$ is the winning percent of the i^{th} team in year t, POP_WPCT_{it} is an interaction term which interacts the estimated CMSA population of team *i* in year *t* with the winning percentage of team *i* in year *t*. The variable POP_WPCT_{it} is intended to capture the market size effect on the value of a win. Burger and Walters (2003, 2008) and Solow and Krautmann (2007) demonstrate that MRPs vary according to the market size of the team, in this case larger markets drive larger MRPs. Burger and Walters (2008) incorporate a population winning interaction term to assess market size MRP differentials. Incorporating market size when testing for a "winner's curse" is relevant since the "winner's curse" phenomenon comes about in common value auctions in which the item being bid on is "worth the same amount to all bidders" (Thaler, 1988, p. 192). For example, if the value of a win is larger for the New York Yankees than the Oakland A's any player's performance that produces a win will be worth more to the Yankees as such the players salary can be larger and still not exceed his MRP. The variable *YEAR* is a vector of year dummies, 1990 is the control.

Step 2 of the Scully method determines the degree to which inputs (player skills) affect output (team performance). Assuming the team production function is linear and the player productivities are separable this equation can be written as (3.1.1).

Table 3.1

Summary statistics for equations (3.1.0) and (3.1.1)

Variable	Observations	Mean	Std. Dev	Minimum
TR	548	127.85	54.17	35.18
SLG	548	0.42	0.03	0.34
SO_BB	548	1.90	0.34	1.16
POP	548	6.13	6.68	1.43

Notes: Total revenue of the i^{th} team from Rodney Fort and is adjusted to 2008 dollars and is represented in millions. Population is the CMSA population estimates represented in millions.

Table 3.2

OLS estimates for equation (3.1.1)

Variable			
WPCT	173,000,000*		
	(9.15)		
POP_WPCT	4.000*		
	(10.81)		
Intercept	-13,200,000		
	(-1.21)		
1991	5,892,464	2000	47,100,000*
	(0.71)		(5.91)
1992	8,736,804	2001	59,700,000*
	(1.06)		(7.49)
1993	9,502,998	2002	59,600,000*
	(1.17)		(7.47)
1994	-26,500,000*	2003	65,700,000*
	(-3.27)		(8.24)
1995	-14,300,000	2004	75,900,000*
	(-1.77)		(9.52)
1996	5,214,840	2005	87,800,000*
	(0.64)		(11.01)
1997	20,100,000*	2006	95,400,000*
	(2.48)		(11.97)
1998	23,400,000*	2007	103,000,000*
	(2.94)		(12.98)
1999	36,900,000*	2008	107,000,000*
	(4.62)		(13.45)
R^2	0.71		
N	548		

Notes: Dependant variable is total revenue adjusted to 2008 dollars, *t*-statistic in parenthesis.

$$(3.1.1)\quad WPCT_{it} = \alpha_0 + \beta_1 SLG_{it} + \beta_2 SO\_BB_{it} + \beta_3 CONT_{it} + \beta_4 OUT_{it} + \beta_5 EXP_{it} + \varepsilon_{it}$$

where SLG_{it} is the slugging percentage of the i^{th} team batting and SO_BB_{it} is the ratio of strikeouts to base on balls.[3] Scully (1974) employed two measures to assess player motivation. With the belief that if a team was out of contention, then the player might not be trying as hard, the dummy variable $OUT_{it} = 1$ if the i^{th} team was 20 or more games out of first place, 0 otherwise is intended to capture this effect. While the dummy variable $CONT_{it} = 1$ if the i^{th} team was within five games of first place or was in first place in year t, 0 otherwise is intended to capture the view that players might be more motivated if they had a chance of making it to the post season. The dummy variable, $EXP_{it} = 1$ if the i^{th} team entered the league during the time period of 1990-2008 is included due to fact that it takes expansion teams[4] 7.2 years on average to achieve a 0.500 winning percentage (Fort, 2006). Results for OLS estimates of equation (3.1.1), with *t*-statistics in parentheses:

$$WPCT_{it} = \underset{(7.23)}{0.2133} + \underset{(7.78)}{0.4983}SLG + \underset{(8.24)}{0.0466}SO\_BB + \underset{(12.16)}{0.0594}CONT - \underset{(-14.46)}{0.0607}OUT - \underset{(-3.38)}{0.0194}EXP$$

$$N = 548,\ R^2 = 0.68$$

[3] Scully (1974) employs these two performance variables and in addition Berri and Bradbury (2010) recommend using the strike out to base on balls ratio to measure pitcher performance. To the extent that these measures are biased, the bias will be downward in that the variables might not be capturing some player inputs, such as fielding statistics.

[4] There were four expansion teams over this period, the Colorado Rockies and Florida Marlins entered in 1993 while the Arizona Diamondbacks and Tampa Bay Devil Rays entered in 1998.

The next step differentiates equations (3.1.0) and (3.1.1) to determine the marginal revenue of the average player on the i^{th} team:

$$(3.1.2) \qquad MR_{hitters} = \left(\frac{\partial TR_{it}}{\partial WPCT_{it}}\right)\left(\frac{\partial WPCT_{it}}{\partial SLG_{it}}\right) = (\gamma_1 + \gamma_2 POP_{it})\cdot \beta_1$$

$$(3.1.3) \qquad MR_{pitchers} = \left(\frac{\partial TR_{it}}{\partial WPCT_{it}}\right)\left(\frac{\partial WPCT_{it}}{\partial SO\_BB_{it}}\right) = (\gamma_1 + \gamma_2 POP_{it})\cdot \beta_2$$

where POP_{it} is the CMSA estimated population for the metropolitan area of the team on which player i played in year t.

The MRP of the j^{th} hitter and j^{th} pitcher is represented in (3.1.4) and (3.1.5).

$$(3.1.4) \qquad MRP_{hitters} = ((\gamma_1 + \gamma_2 POP_{it})\cdot \beta_1 \cdot SLG_{jit})\cdot AB\%_{jit}$$

$$(3.1.5) \qquad MRP_{pitchers} = ((\gamma_1 + \gamma_2 POP_{it})\cdot \beta_1 \cdot SO\_BB_{jit})\cdot IP\%_{jit}$$

where $AB\%_{jit}$ is the percentage of team i at bats in which player j batted in year t and $IP\%_{jit}$ is the percentage of team i innings pitched by player j in year t. Using equations (3.1.4) and (3.1.5) to measure a player's MRP allows for the market size affect to be incorporated into player MRP such that the MRP of any given player will be larger for large market teams. For example, in 2001 Jason Giambi became a free agent and was signed for 1 year to the Oakland A's. Then in 2002 Giambi signed with the New York Yankees. Giambi's 0.660 slugging average in 2001 would produce \$5.76 million in marginal revenue for the A's and $7.6 million if he had a .660 slugging average for the Yankees.

Studies into MLB player MRP have by and large focused on players in the later half of their careers, particularly the years in which the player is eligible for free agency. Since players in the first 6 years of their MLB career are bound to the team that initially drafted them, these players tend to receive salaries near the league minimum for at least the first 3 years of service prior to arbitration eligibility which occurs after the 3rd year. The player is still bound by the reserve clause for years 3 through 6 their salaries tend to be somewhat lower than free agent salaries. If teams are exploiting player services in the first 6 years then we should see total marginal revenue products for players in the first 6 years of service to exceed salaries over these first 6 years. Table 3.3 shows player MRP calculated using equations (3.1.4) and (3.1.5) for players over their first 6 years of MLB service. The yearly MRP estimates are summed over the first 6 years of the player's career. Returns are calculated as the sum of the total marginal revenue produced by the player minus the salary invested in the player by the team over the first 6 years of the player's career. The proportion of returns to investment is given in the final column.

An economically efficient labor market would produce a zero total return, in such a market the player would be receiving a salary equal to his MRP. Table 3.3 provides some evidence that at least over the first 6 years of a players MLB career the market is inefficient, though in a direction opposite to that of a "winner's curse" in that returns are positive and the return to salary investment exceeds 0%. In all cases returns are positive, most likely due to the institution mandating that a player is only eligible for unrestricted free agency after they have been playing in MLB for 6 seasons. The Los Angeles Angels

Table 3.3

Returns to players over the first 6 years of MLB service

TEAMS	Developed Players	Total Salary	Total MRP	Total Return	$\frac{RETURN}{SALARY}$
LA-Angels	153	$651	$1,570	$921	142%
Pittsburgh	156	$431	$1,000	$571	132%
Montreal/Nationals	157	$497	$1,120	$625	126%
San Diego	141	$457	$1,020	$565	123%
Tampa Bay*	88	$255	$560	$305	119%
Milwaukee	155	$500	$1,090	$589	118%
Florida*	127	$419	$909	$490	117%
LA-Dodgers	139	$621	$1,330	$711	114%
NY-Mets	121	$516	$1,070	$556	108%
Houston	135	$535	$1,070	$533	100%
Minnesota	136	$599	$1,160	$558	93%
San Francisco	129	$467	$890	$423	91%
Philadelphia	163	$702	$1,310	$612	87%
Kansas City	134	$506	$928	$423	84%
Colorado*	130	$515	$928	$413	80%
Seatle	138	$583	$1,030	$447	77%
Oakland	165	$681	$1,200	$516	76%
Texas	146	$656	$1,150	$496	76%
Cleveland	173	$780	$1,370	$586	75%
Detroit	152	$630	$1,100	$473	75%
Toronto	163	$795	$1,390	$593	75%
Cincinnati	159	$698	$1,200	$504	72%
Chi Cubs	150	$728	$1,210	$478	66%
Atlanta	136	$687	$1,130	$446	65%
Baltimore	138	$647	$1,050	$403	62%
Boston	161	$856	$1,390	$531	62%
Chi White Sox	170	$922	$1,490	$567	61%
Arizona*	65	$271	$433	$162	60%
NY-Yankees	121	$794	$1,260	$465	59%
St. Louis	130	$598	$934	$336	56%

Notes: ($Millions). Included players signed between 1990 and 2008. * = expansion team between 1990 and 2008. The Montreal Expos folded in 2004 and became the Washington Nationals, some players signed with the Expos then moved directly to the Nationals and these players were included as having played for the same team for the first 6 years of MLB service.

appear to be generating the most return to investment while the St. Louis Cardinals are generating the least. Table 3.3 also tells a story about how teams think it best to produce a winning team. Some teams prefer to develop young players from the time they enter the league hoping to find a diamond in the rough while other teams prefer to work the free agent market and acquire proven players, a strategy often more expensive. The column Developed Players sums the number of players with less than 7 years on a particular team over the time period form 1990 to 2008. The Cleveland Indians and Chicago White Sox appear to prefer the development method by developing at least 170 players over this period. Excluding expansion teams, and not surprisingly, the big spending Yankees and Mets top the list of developing the fewest players with 121, preferring to look to the free agent market to build their teams. The large positive returns are due to the monopsony power the league exercises through the 6-year reserve requirements. The question to be addressed in the next section is whether amateur free agents, generally players coming from Latin American or Caribbean countries, are producing different returns to team investment than are players who enter MLB through the draft.

3.3 The "Winner's Curse" and the Return to Investment

To test the hypothesis of a "winner's curse" in the market for foreign born baseball players and to more formally analyze the return to investment in drafted and undrafted players, equations (3.1.4) and (3.1.5) are again used to compute player MRP for each year of the player's career. If undrafted foreign born players, amateur free agents, are producing different returns to team investment then regressing individual salaries on player MRP should fail to reject the hypothesis that the intercept is equal to 0 and the slope equal to 1.

(3.1.6)
$$\begin{aligned} SAL_{jit} &= \mu_0 + \mu_1 MRP_{jit} + \mu_2 FA\_MRP_{jit} + \mu_3 IFP\_MRP_{jit} \\ &+ \mu_4 CHANGE_{jit} + \mu_5 FA\_CHANGE_{jit} + \mu_6 IFP\_CHANGE_{jit} \end{aligned}$$

Player salaries and player MRP are then summed, producing SAL_{jit} and MRP_{jit} over four different time periods in a player's career, the first 3 years of a player's career (Model A), the 4th, 5th and 6th year of a player's career (Model B), the first 6 years of a player's career (Model C), and the years after the first 6 years of the player's career (Model D). Model C contains the same players as Model B but salary and MRP are summed over the entire 6-year period for Model C and only over the 4th, 5th and 6th season of a player's career in Model B. All the players in Model B will also be included in Model C, but it could be the case that a player exited the league after their third season in which case they would be included in Model A but not Model B or C. These groupings are made due to labor market regulations particular to MLB. Incoming player contracts are subject to being reserved for the first 6 years of the player's career. A player with at least 3 years of experience playing in MLB but less than 6 years is eligible to renegotiate his contract with his current team. While a player with more than 6 years of MLB service is eligible to shop his services to any team as a free agent. Table 3.4 describes the variables. Amateur free agents are typically players from Latin American and Caribbean countries, the primary countries being Venezuela and the Dominican Republic. The foreign born free agents and purchased players are generally players

Table 3.4

Variable descriptions

Variable	Definition
SAL_{jit}	Total salary of player *j* earned over time period *t*
MRP_{jit}	Total MRP (computed from equations 3.1.4 and 3.1.5) of player *j* over time period *t*
FA_MRP_{jit}	Interaction term computing the total MRP of player *j* over time period *t* for players entering MLB as amateur free agents.
$FPUR\_MRP_{jit}$	Interaction term computing the total MRP of player *j* over time period *t* for players entering MLB either as foreign free agents or as players whose contracts were purchased from teams in leagues outside the United States.
$CHANGE_{jit}$	A dummy variable equal to 1 if player *j* played for a team other than the team that originally signed or drafted him during time period *t*.
FA_CHANGE_{jit}	A dummy variable equal to 1 if player *j* entered MLB as an amateur free agent and played for a team other than the team that originally signed him during time period *t*.
$FPUR\_CHANGE_{jit}$	A dummy variable equal to 1 if the player the player is a foreign born free agent or a purchased player and played for a team other than the team that originally signed him during time period *t*.

coming from the Nippon Professional League (NPB) of Japan, 20 players, while a few, 6 players,[5] come from Liga Mexicana de Beisbol in Mexico. These two are grouped together because in order for an MLB team to acquire one of these players contracts, the MLB team needs to pay a transfer fee to the International team. In the case of NPB, if a player is drafted by an NPB team then that player has to become an International free agent before they will be permitted to sign with any non NPB team. To become an International free agent a player has to play for nine seasons in the NPB (Klein, 2006, p. 138); more often than not these are Japanese players but this does not have to be the case.[6] Due to the 9 years that a player has to play in Japan we should expect that the players in this category would have provided MLB teams with ample opportunity to assess their skill level and potential in MLB. This should contrast with the lesser known potential of Dominican or Venezuelan players who have had less chance to display their MLB potential.

The team change dummies are included to try and tell the story of a player's MLB career. It could be the case that poor performing teams who draft high will draft talented

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[5] The descriptive statistics have two extra observations these come from players whose contracts were purchased from a Canadian team, George Sherill, and an unaffiliated minor league team, Terry Leach.

[6] In the data set there were two players who were not Japanese nationals who were drafted by an NPB team, Alphonso Soriano and Timo Perez. Both of these players are Dominican nationals and both played for the Hiroshima Toyo Carp. The Dominican born Alphonso Soriano initially signed with the Hiroshima Toyo Carp and due to the rule that the player has to play with an NPB team for 9 years Alphonso was probably going to be stuck playing the Carp's academy team for a few years, then having to put in his 9 years with the NPB Carp. To circumvent this issue Alphonso put in for early retirement with the Carp intending to sign with an MLB team. For NPB teams if a player retires before achieving free agency the team owns the rights to the player's contract into perpetuity. In the case of Soriano, MLB intervened and the New York Yankees were able to buy out Soriano's contract from the Carp (Klein, 2006).

players and then sell these player's contracts early on to try and reap a financial benefit from the draft which would show up with a positive coefficient in the early years of a player's contract for drafted players. This could also be the case for amateur free agents who a team may discover but feel that they would receive a larger financial benefit from selling this contract to another team. Descriptive statistics for equation (3.1.6) are reported in Table 3.5.

The descriptive statistics are revealing in that over the first 3 years of a player's MLB career, he is receiving much less in salary than he is producing in MRP. The difference in total salary and total MRP between drafted players and amateur free agents is not very large while the amount of total salary earned for international free agents is about \$3.5 million more and the production in terms of MRP is less than \$2 million more. For all players the salaries jump up notably in the 4^{th}, 5^{th} and 6^{th} years of their contracts. This is most likely due to arbitration eligibility after their 3^{rd} year. Even though the number of observations is fairly low for International players during these years, the mean total salary exceeds the mean MRP. Over the course of the first 6 years, mean total salary and mean total MRP are similar for amateur free agents and drafted players. In the case of the international free agent, the average productivity is very close to the average total salary. As one would expect, once players are allowed to enter a free labor market (after playing for 6 years) the mean salaries jump up dramatically for amateur free agents and drafted players far exceeding the mean MRP for these groups. The lower MRP in the more than 6 years of MLB service group relative to the players with 6 years total experience are most likely due to the structure of the more than 6 years group in that these players have often played less than 6 total years as free agent eligible players. For

Table 3.5

Descriptive statistics for equation (3.1.6)

	Players	Mean Total Salary	Mean Total MRP	# Change Teams
Players with 3 or less years of MLB service				
All Players	1997	$1,598,633	$5,303,830	1233
Amateur Free Agents	388	$1,495,363	$5,344,906	251
International Free Agents	28	$5,103,807	$7,009,722	14
Players with more than 3 and less than 7 years of MLB service				
All Players	1117	$5,821,334	$7,104,941	866
Amateur Free Agents	227	$5,771,305	$7,047,435	174
International Free Agents	14	$10,600,000	$7,117,744	12
Players with 6 years of MLB service				
All Players	1117	$7,434,486	$13,200,000	866
Amateur Free Agents	227	$7,219,759	$12,900,000	174
International Free Agents	14	$15,100,000	$15,800,000	12
Players with more than 6 years of MLB service				
All Players	914	$18,500,000	$10,300,000	827
Amateur Free Agents	188	$19,100,000	$10,030,000	177
International Free Agents	9	$11,000,000	$5,496,121	8

this reason, a further independent variable, *SEASONS* = number of seasons played in MLB, is added to Model D. The mean total salary for international players drops relative to the first 6 years and the mean total MRP drops quite dramatically, again probably due to having fewer years to accrue MRP as a free agent but also might have something to do with these players having played professional baseball, in the US and Japan for over 15 years by this point.

The coefficients, μ_1, μ_2 and μ_3 can be used to calculate the return to investment in player services. The player produces 1 unit of MRP, of that 1 unit the player receives a portion equal to μ_1, $\mu_1 + \mu_2$ or $\mu_1 + \mu_3$ depending on group, which is the portion of a players MRP he receives as salary. The profit the team receives is the portion of the players MRP less his salary, $1 - \mu_1$, $1 - (\mu_1 + \mu_2)$ or $1 - (\mu_1 + \mu_3)$. The percentage return to investment (ROI) is then: $ROI = \frac{1-\mu_1}{\mu_1} \times 100$ for all players and

$$ROI = \frac{1-(\mu_1 + \mu_i)}{(\mu_1 + \mu_i)} \times 100$$ for the group coefficients. An efficient market would be the situation in which $ROI = 0$, a player would receive the full value of his production and the team would receive the full value of their investment. Inefficiencies occur when $ROI \neq 0$. A "winner's curse" would be consistent with $ROI < 0$ while $ROI > 0$ is consistent with player exploitation. If $\mu_1 < 1$ then the team will be receiving a larger return, in terms of MRP, to their investment in salary and the player will not be receiving the full value of his contribution. The case of $\mu_1 > 1$ is the case of the "winner's curse", whereby the team is receiving a return to investment, in terms of MRP, that is less than the investment. The OLS estimations of equation (3.1.6) are reported in Table 3.6, Table 3.7, Table 3.8 and Table 3.9. In addition to reporting *t*-statistics, Table 3.6, Table 3.7,

Table 3.8 and Table 3.9 include Wald tests, H_0: $\mu_1+\mu_i = 1$, on the coefficients μ_1, μ_2 and μ_3 to determine if these coefficients are significantly different from 1.

Looking first at Model A (first 3 years of service) the MRP coefficient for all players, pitchers only and hitters or position players are significant at the 1% level and are significantly less than one at the 1% level. In the case of all players, each dollar of MRP generated yields only \$0.23 in salary thus the team profits \$0.77 (0.77=1-.23) on each dollar invested which in turn means a return to investment, $ROI_{ALL} = 327\%$. Position players in this group produce a larger return than pitchers, $ROI_{HITTERS} = 297\% > ROI_{PITCHERS} = 231\%$ but the best bang for your player dollar is with the amateur free agent. Taken as a whole (pitchers and position players) these players produce a $ROI^{FA}_{ALL} = 446\%$ or a profit of \$0.82 (0.82=1-(.234-.05)), for every dollar a team spends on an amateur free agent. In this group, the coefficient on amateur free agent MRP is insignificant for pitchers but is significant for position players, suggesting most of the effect on the return to amateur free agents comes from position players, $ROI^{FA}_{HITTERS} = 405\%$. In the case of international free agents, teams seem to be operating more efficiently bringing economic profits closer to zero with a return on investment of 49%. A positive return 49% is still a wise investment from a profit seeking team owner's perspective. It does not appear that international free agents are cursing the team with a salary that exceeds their MRP. One could suspect here that the information gathered by MLB general managers watching these players play in Japan is allowing them to make reasonably accurate estimates of these players MRP, though we will see in later models that this is probably not the case. The *CHANGE* team dummy variable is significantly positive in the all player specification, the pitcher only specification and the hitter only

Table 3.6

Model A, players over their first 3 years

	Model A		
	ALL	PITCHERS	HITTERS
MRP	0.234** (20.26)	0.302** (13.52)	0.252** (17.28)
F-test, H_0: μ_1=1	4396.55**	978.03**	2621.61**
FA_MRP	-0.051* (-2.54)	-0.035 (-0.86)	-0.054* (-2.35)
F-test, H_0: μ_1+ μ_2=1	1725.49**	349.01**	1174.69**
IFP_MRP	0.436** (10.01)	0.024 (0.25)	0.528** (11.06)
F-test, H_0: μ_1 + μ_3=1	58.45**	50.52**	21.24**
CHANGE	$482,807** (5.24)	$440,224** (3.28)	$520,251** (4.22)
FA_CHANGE	$234,209 (-1.45)	$199,586 (-0.86)	$247,373 (-1.1)
IFP_CHANGE	-$570,816 (-1.08)	$1,306,164 (1.87)	-$1,915,565 (-1.81)
Constant	$43,546 (0.46)	$119,328 (0.88)	-$365,817** (-2.71)
Observations	1997	939	1058
R-squared	0.24	0.19	0.32

Notes: Dependant variable is total salary. *t*-statistics in parentheses,* significant at 5%; ** significant at 1%.

Table 3.7

Model B, players in their 4th, 5th and 6th years

	Model B		
	ALL	Pitchers	hitters
MRP	0.595**	0.727**	0.706**
	(21.01)	(14.58)	(20.21)
F-test, H_0: μ_1=1	204.55**	29.97**	70.74**
FA_MRP	-0.072	-0.017	-0.098*
	(-1.59)	(-0.18)	(2.06)
F-test, H_0: $\mu_1 + \mu_2$=1	116.91**	9.49**	66.68**
IFP_MRP	1.13**	-0.323	1.661**
	(6.82)	(-0.38)	(9.43)
F-test, H_0: $\mu_1 + \mu_3$=1	19.29**	0.50**	59.87**
CHANGE	-$1,046,782**	-$978,973	-$994,722**
	(-3.36)	(-1.95)	(-2.77)
FA_CHANGE	$734,707	$336,250	$1,117,623*
	(1.66)	(0.49)	(2.03)
IFP_CHANGE	-$5,390,986**	$2,286,784	-$17,200,000**
	(-3.49)	(-0.66)	(-6.49)
Constant	$2,350,950**	$2,904,592**	$350,730.67
	(6.60)	(5.43)	(-0.77)
Observations	1117	486	631
R-squared	0.37	0.36	0.51

Notes: Dependant variable is total salary. *t*-statistics in parentheses,* significant at 5%; ** significant at 1%.

Table 3.8

Model C, players over their first 6 years

	Model C		
	All	Pitchers	Hitters
MRP	0.511** (26.25)	0.669** (18.64)	0.593** (26.82)
F-test, H_0: μ_1=1	631.46**	85.02**	338.36
FA_MRP	-0.064* (-2.00)	-0.005 (-0.07)	-0.076* (-2.42)
F-test, H_0: μ_1+ μ_2=1	303.20**	24.40**	218.41**
IFP_MRP	0.767** (8.46)	-0.481 (-1.56)	0.985** (11.64)
F-test, H_0: μ_1 + μ_3=1	9.55**	7.02**	46.99**
CHANGE	-$307,782 (-0.83)	$165,202 (-0.28)	-$469,484 (-1.18)
FA_CHANGE	$1,183,396* (2.15)	$529,330 (0.63)	$1,633,099* (2.51)
IFP_CHANGE	-$8,791,004** (-4.79)	$5,479,706 (1.55)	-$19,300,000** (-7.35)
Constant	$843,001 (1.95)	$837,227 (1.26)	-$1,835,295** (-3.58)
Observations	1117	486	631
R-squared	0.46	0.45	0.63

Notes: Dependant variable is total salary. *t*-statistics in parentheses,* significant at 5%; ** significant at 1%.

Table 3.9

Model D, players with more than 6 years

Model D			
	All	Pitchers	Hitters
MRP	1.695** (31.83)	1.444** (22.33)	2.32** (29.85)
F-test, H_0: μ_1=1	170.41**	47.12**	288.40**
FA_MRP	0.114 (1.48)	0.66** (4.75)	-0.017 (-0.19)
F-test, H_0: μ_1+ μ_2=1	101.26**	62.04**	169.39**
IFP_MRP	-0.124 (-0.2)	0.274 (0.27)	-0.153 (-0.19)
F-test, H_0: μ_1 + μ_3=1	0.84	0.49	2.10
CHANGE	-$3,780,104** (-2.71)	-$6,622,634** (-3.27)	-$3,092,958 (-1.89)
FA_CHANGE	$534,550 (0.42)	-$2,141,913 (-1.46)	$1,910,347 (1.09)
IFP_CHANGE	$2,648,304 (0.48)	-$391,290 (-0.07)	$457,903 (0.05)
SEASONS	$306,942 (1.36)	$1,527,536** (6.26)	-$2,492,383** (-7.26)
Constant	$842,406 (-0.37)	-$3,098,248 (-1.07)	$18,746,760** (6.05)
Observations	914	381	533
R-squared	0.78	0.82	0.82

Notes: Dependant variable is total salary. *t*-statistics in parentheses,* significant at 5%; ** significant at 1%.

that this is probably not the case. The *CHANGE* team dummy variable is significantly positive in the all player specification, the pitcher only specification and the hitter only specification but loses statistical significance when the player groups are individually considered. In Model A there is no evidence of a "winner's curse" in any group. Rather the contrary seems to be the case: Teams are paying less than what they receive in return in terms of MRP with the amateur free agent producing the largest returns.

When players are first allowed to engage in arbitration after their third year but are not yet unrestricted free agents, Model B, the return to investment approaches more economically efficient values. All players produce a 68% return, pitchers produce a 38% return and position players produce a 42% return. It should be noted here that the return to all players is not the average of the return to pitchers and position players due to the larger number of hitters relative to pitchers in the data set. The return to all players is either driven down by hitters, when the coefficient on MRP for hitters is less than the coefficient on MRP for pitchers or driven up when the opposite is true, which we will see in when looking at Model D.

Profit maximizing team owners would be wise to build a team with drafted players and amateur free agents from this group but appear to be making unwise decisions when it comes to international free agents. For international free agents in their 4^{th}, 5^{th} and 6^{th} years, the Wald test shows that $\mu_1 + \mu_2$ is significantly different from 1 at 1% and $ROI_{ALL}^{IFP} = -42\%$ which is consistent with a "winner's curse" for international free

agents during this time of their career. *ROI* gets larger negatively when we look at the international position players only specification, $ROI_{HITTERS}^{IFP} = -58\%$. The profitable signing of international free agents seems to disappear after their 3rd year in MLB. Could age be catching up with the international free agents? Remembering that most of these players have already played professional baseball in Japan for 9 years and then adding in the 3 years of at least 162 MLB games these players could simply be nearing the end of their careers when they enter MLB. The "winner's curse" for international players could be due to general managers and talent scouts not taking into account the mileage in professional baseball these players have accrued over their careers. In Chapter 7 of Baseball Prospectus' *Baseball Between the Numbers*, it is estimated that the age at which an offensive player hits his peak is between age 26 and 29.

> A typical hitter can expect to experience rapid improvement through age twenty-three and continued steady improvement through age twenty-six. He will then typically see his performance plateau between ages twenty-six and twenty-nine. (Silver, 2006, p. 263)

If a Japanese player begins his career at age 17 then he will be evaluated by MLB talent scouts in his 8th and 9th year which puts him on the upward trend of his career performance, age 25 and 26. Then he hits his peak in his first 3 seasons in MLB between 26 and 29. After those first three seasons he begins to decline and the contract he signed when he entered is now providing him with too large of a salary relative to his performance in years 4, 5 and 6 of his MLB career. Noting from Table 3.5 that the mean international free agent total salary is much larger in years 4 through 6 it could be the case that after the 3rd year, when players can renegotiate their contracts based on performance, teams overpay based on an expectation of an upward trend for player performance like what one might expect for a domestic player.

Players who change teams in their 4th, 5th or 6th year lose a significant amount of salary which is a surprising result since changing teams positively affected a player's salary if they changed teams in the first 3 years. The salary with which a player enters the league and the revenue potential of the team he signs with could be driving this result. The ability of any entering player to perform at the major league level is to some degree unknown. We could imagine a case where a small market, poor performing team drafts a player high and pays him a high salary thinking his marginal productivity will be large enough to support the high salary but after 3 years the team realizes his marginal productivity is not high enough in their market but is high enough to produce an MRP more in line with his salary in a larger market. The team that owns his contract for the first 3 years could then sell his contract to the larger market team for the value of the contract, which in a market with a larger revenue potential his marginal productivity could be worth the higher salary. The very large decrease in an international player's salary when he changes teams could be a similar phenomenon only larger due to the much larger initial salary of the international player. Table 3.4 shows that the mean total salary for an international player over his first 3 years is \$5 million while the mean total salary for all players is \$1.6 million.

Model C includes players over the first 6 years of their MLB careers. The coefficients on *MRP* are significant for all three specifications. *FA_MRP* is significant and negative when all players are included and when only position players are included. *IFP_MRP* is significant and positive when all players are included and when only position players are included. The *R*-squares are highest in Model C, suggesting this could have the most explanatory power of the Models discussed so far. Looking first at MRP we see *ROI* < 1 for all three specifications, $ROI_{ALL} = 96\%$, $ROI_{PITCHERS} = 49\%$, $ROI_{HITTERS} = 69\%$ with position players being more profitable on average than pitchers.

We see that over the first 6 years of a player's MLB career, amateur free agents produce the highest rates of return as a group, $ROI_{ALL}^{FA} = 124\%$, and amateur free agent position players produce the highest returns for position players $ROI_{HITTERS}^{FA} = 93\%$ over the first 6 years their MLB service. The international free agents, although still generating negative returns, generate lower negative returns when the entire 6-year period is considered, $ROI_{ALL}^{IFP} = -22\%$ in general and as far as position players go, $ROI_{HITTERS}^{IFP} = -37\%$. So far it seems to be the international free agent who is cursing teams by generating less MRP than they are producing.

One interesting development in Model C is again the *CHANGE* variable; there is no significant effect of this for players grouped together, but amateur free agents receive a significant and positive salary increase when they change teams while international free agents receive a significant salary decrease when they change teams. As noted above a player receiving a high salary is more likely to under perform his salary than a player receiving a low salary, while a player with a low salary is more likely to out perform his salary. The small market team can sell the low salaried amateur free agents contract for a higher value to a higher revenue team based on his performance while the smaller market team can sell a high salaried player to another team for a value equal to his performance but lower than his salary, thereby dumping a high salary for something in return.

Model D looks only at players who are eligible for free agency, players with at least 6 years of MLB experience. The high *R*-squares in this model suggest a fairly accurate specification of the player performance variables of strike-outs/base-on-balls and slugging percentage. This argues that players are paid in accordance with their marginal productivity in terms of strike-outs/base-on-balls and slugging percentage.

Looking back on the low *R*-squares in Model A relative to Model D suggests that inconsistencies in expected marginal productivity rather than inaccurate model specification could be the reason behind the low *R*-squares. One would think though, that after watching a player play in MLB for 6 seasons, general managers would have a fairly accurate view of a player's ability to produce at the MLB level. The significantly larger than 1 coefficient on *MRP* suggest otherwise.

For players eligible for free agency, we see results consistent with a "winner's curse" in all three specifications and subsequently negative rates of return in all three specifications, $ROI_{ALL} = -41\%$, $ROI_{PITCHERS} = -31\%$, $ROI_{HITTERS} = -57\%$. In Model D, the affect of being an international free agent has no significant impact on the relationship of player MRP and salary, but amateur free agent pitchers are overpaid \$0.66 for every dollar of MRP they produce and also have a highly negative *ROI*, $ROI^{FA}_{PITCHERS} = -52\%$. It seems that the high positive rates of return for amateur free agents in their first 6 years of service is negated when they have been playing in the league for more than 6 years. A player who chooses to change when they become eligible for free agency has a statistically significant negative impact on a player's salary. One could suppose that a team who signed or drafted a player when they entered the league then kept that player on their team for 6 seasons would have fairly accurate knowledge of their expected productivity, thereby not contracting a player in free agency and sending the player into the market where he then receives a lower contract when he signs with another team. The variable *SEASONS*, which was added to this model and not the others is significant and positive for pitchers but significant and negative for position players. This could be due to a larger amount of predictability in pitcher play as the pitcher ages and a smaller amount of predictability as a hitter ages. As a pitcher ages he can get more 'savvy'[7] allowing him to continue playing whereas as a hitter ages he might lose some of his bat speed which would make him progressively less productive as he ages.

3.4 Conclusion

So what do these results tell us about rates of return, the "winner's curse" and building a profitable MLB team? First in regard to the rate of return to investing in players, the maximum rate of return comes from amateur free agents in their first 3 years ($ROI_{ALL}^{FA} = 446\%$). If a team wanted to maximize the rate of return for investment in players it would fill out its 40-man roster with amateur free agents, having to go to Latin America and the Caribbean to do this. Of course we might suppose there are some intangibles with this method. A team of 40 kids aged 18 to 20 years old might pose some problems that OLS regressions were unable to uncover.[8] More realistically one should look to players with less than 7 years of MLB experience, Model C. A team would maximize returns by building the team around this group by selecting pitchers through the draft ($ROI_{PITCHERS} = 45\%$) and position players as amateur free agents, $ROI_{HITTERS}^{FA} = 93\%$. If teams chose this method then for each dollar of revenue produced from the pitching staff the team would receive \$0.33 (0.33=\$1-\$0.67) paying the pitcher \$0.67 for each dollar produced. The position players coming in as amateur free agents

[7] Jamie Moyer is still pitching in MLB at age 48 and Tom Glavine, who retired in 2008 pitched for 22 years.

[8] In some sense there is a precedent for this. In the 1991-92 season the University of Michigan played five freshman basketball players on their team, Chris Webber, Jalen Rose, Juwan Howard, Ray Jackson and Jimmy King. The team made it to the final four, losing to Duke.

would receive \$0.51 (0.51=\$0.59 - \$0.8) for each dollar they produced and the team would receive the remaining \$0.49. The growth of players from Latin America and the Caribbean could be due to teams wishing to maximize rates of return and places like the Dominican Republic and Venezuela are places where they can, through amateur free agency, fill in their position player roles, relying on the draft for pitchers.

The last thing a team wishing to maximize the rate of return would ever want to do is sign a player who has been playing in the league for more than 6 years and is thus eligible for unrestricted free agency. Results from Model D are consistent with a "winner's curse" for all specifications with the most cursed players, those with largest negative returns to investment being pitchers who entered MLB as amateur free agents, $ROI_{PITCHERS}^{FA} = -52\%$ and drafted position players, $ROI_{HITTERS} = -57\%$. In addition to unrestricted free agents, the international free agent produces a "winner's curse" over the first 6 years of MLB service.

The results of the above analysis are then that amateur free agents produce the largest "bang for a teams buck" but once these players have been playing in the league for 6 years and are competing with unrestricted free agents in the labor market these players, along with the other unrestricted free agents, curse the teams that sign them. It does not seem to be too much of a stretch that team owners and general managers in MLB use their monoposony power to exploit the amateur free agent, but why would a team hire an unrestricted free agent? It could be that players who have been in the league for more than 6 years bring something intangible to the clubhouse. Maybe the experience of playing so long has value to players who have not been playing as long producing some sort of synergistic effect. A team that believes in such synergy and wants to go ahead and lose money on an unrestricted free agent signing to have clubhouse leadership could balance an unrestricted free agent signing with an amateur free agent signing. The high rates of return for amateur free agents will work toward balancing out the negative rates of return from high salary unrestricted free agent signings. As the number and salaries of unrestricted free agents rise, teams could be turning to the academies in the Dominican Republic and Venezuela for amateur free agents who can fill in as position players and use the draft to bring in new young pitchers who then can learn from the more seasoned pitchers. Looking back at Figure 1.1, and noting that “48 percent of players under Minor League contracts -- or, 3,370 of 7,026 -- were born outside the U.S” (MLB.com), and that 14 of the 32 first round selections of the 2010 draft were pitchers MLB might already be employing this method of team building.

In the case of the international free agents we do not see the monopsony exploitation even though they are subject to the same reserve rules (i.e., 6 years of MLB service) as all the others. International free agents are producing negative returns relative to other players with less than 6 years of MLB experience. This could be a classic case of the “winner’s curse” whereby the winning bid exceeds the expected value of the player. Teams could be basing this international player’s salary on his expected performance, but failing to adjust for the fact that for the first 3 years in MLB he will be in his peak, but the next 3 years he will begin to decline. Teams could be basing their expectations of a player’s performance as though the international free agent is a 23- or 24-year-old player who was slowly brought along by minor league teams when in fact he is a 26- or 27-year player who very likely, due to his high skill level, was a workhorse for his Japanese team for 9 years before entering MLB. The 6-year reserve institution could be exacerbating this phenomenon by forcing teams to sign these players for 6 years when they would be better served by only signing them for 3 years then adjusting downward their MRP estimates.

What about an international draft? The Blue Ribbon Panel report suggests as one of its guidelines for changes in MLB to enhance competitive balance within the league that MLB institute an International reverse order draft to enhance competitive balance. Though this paper does not speak to competitive balance issues of the draft, leaving that question for future research, it does argue that the Rule 4 draft allows players to access more of their MRP than those players who enter as amateur free agents. Over the first 6 years of a position player's career, the amateur free agent loses \$0.08 of every dollar of marginal revenue he produces relative to the drafted player. This underpayment could be seen as a return to training amateur free agents, since the mean time training as measured by the number of years between a player entering MLB as a contracted player and that players debut game in MLB is 4.63 years for amateur free agents and 3.54 years for a drafted player. An international reverse order draft could reduce this training time by establishing minimum age requirements for international players like it does for domestic players.

On the other hand, an international reverse order draft could negatively affect the academy system, which although imperfect, does manage to find young talented players. At present funding for an academy in the Dominican Republic or Venezuela is provided by individual MLB teams. It is unlikely that a team would wish to continue this funding if there was a chance they could lose a player they paid to train to another team through the draft. This problem could be ameliorated if MLB enacted a policy to divert some revenue to the academy system, so that the academies were not individually funded by individual teams but rather equally funded by all teams. Future research could take up this question looking at Puerto Rico as a case example of what happens when a draft is installed after years of no draft, as it was in 1991.

An international reverse order draft could benefit poor performing teams by allowing these teams to sign the best foreign players and keep them in their organization for the 6 years of their MLB service. The positive returns to amateur free agents over drafted players from the above analysis suggests that teams are doing quite well in exploiting these players already, possibly through the brute force method noted above by Klein which would be eliminated with a reverse order draft. Teams would be unable to sign large numbers of young foreign players from which they can sift and determine which players would be best for their teams. It might be that returns over the first 6 years of a player's contract for amateur free agents are higher because these are the players who, after the sifting process, have shown to be the most talented. A draft only allows a team to sign one player each round and might eliminate the cost effectiveness of the brute force method. We do see that even though MLB exercises its monopsony power over drafted players as well as the undrafted amateur free agents it exercises it to a larger extent over the undrafted amateur free agents.

One possible method of reducing the low returns and the "winner's curse" to international free agents and purchased players could be to extend the already established Rule 5 draft which applies to professional players and is held yearly in December. The Rule 5 draft is for players who have played for 4 years in the minors and are presently not on the 40-man roster. It would seem to be a natural extension to NPB players since these players are professionals with 9 years of professional baseball experience.

It is possible that by including Japanese Professional League players in the rule 5 draft the negative returns to these players could be reduced, in effect transferring those returns to the other international players and cover the extra positive returns generated by the players who are at present amateur free agents. For example, looking at Model C, we see that $ROI_{ALL}^{FA} = 124\%$ and $ROI_{ALL}^{IFP} = -22\%$. International free agents receive \$1.28 (=.511+.767) for every dollar of MRP they produce while amateur free agents receive \$0.45 (=.511-.064) for every dollar of MRP they produce. There is certainly room for a \$0.06 transfer to the amateur free agent bringing their return and degree of exploitation more in line with the young drafted players and still rewarding the international free agent for their years of service in professional baseball.

In sum, this research demonstrates results which are consistent with a winners curse in the market for international free agents and unrestricted free agents. The amateur free agent on the other hand provides the largest bang for a team's buck by providing an \$0.82 profit to the team for every dollar in salary invested. In regard to building a profitable team, a team should be built around players with less than 6 years experience, doing this by getting pitchers through the draft and position players through amateur free agent market. Teams wishing to make a profit should avoid the international player market and the unrestricted free agent market, but if for some reason they wish not to do this teams can balance their balance sheets by offsetting unrestricted free agent signings with signings of young Dominican and Venezuelan players. An international reverse order draft could transfer some of the MRP presently produced by amateur free agents from the team to the player. On the other hand, an international draft could harm teams that depend on the exploitation of amateur free agents to increase their overall returns but this effect could be reduced by extending the rule 5 draft to players in NPB.

CHAPTER 4

THE FALL OF THE WALL: COMPETITIVE BALANCE IN THE NATIONAL HOCKEY LEAGUE THE RUSSIAN ELITE LEAGUE AND THE CZECH REPUBLIC LEAGUE

4.1 Introduction

As mentioned in the literature review, the most common measure to determine league parity involves the standard deviation of winning percentages[1] first introduced by Noll (1988) and further developed by Scully (1989) and Fort and Quirk (1992, 1995). Maximum uncertainty occurs when each team is equally talented and as such the outcome of the game is a random variable. Fort and Quirk (1992, 1995) apply this methodology by looking at the distribution of wins in a sports league as measured by the standard deviation of end of season winning percentages, σ_{actual}. Due to the fact that different leagues play a different amount of games σ_{actual} needs to be adjusted if leagues and different time periods are to be compared. Fort and Quirk (1992, 1995) adjust the actual standard deviation of winning percentages with an idealized standard deviation intended to capture competition in a league of perfectly equal competitors. "That is, the

[1] "The measure most commonly used by economists over the years has been something called "the standard deviation of winning percentages" (Szymanski & Zimbalist, 2006, p. 173).

idealized measure applies to a league in which, for each team, the probability of winning any game is one-half" (Quirk & Fort, 1997, p. 245). The idealized standard deviation is defined as, $\sigma_{ideal} = \dfrac{0.5}{\sqrt{games}}$. The actual standard deviation of winning percentages, σ_{actual}, is then divided by the idealized standard deviation, σ_{ideal}, to result in the measure of competitive balance, *R*, where, $R_t = \dfrac{\sigma_{actual}}{\sigma_{ideal}}$. As *R* moves toward unity from above the league is said to be more competitively balanced.

This chapter intends to address the computation of the ideal standard deviation. The Fort and Quirk measure computes the ideal standard deviation assuming a binomial outcome of either a win or a loss and as such $\sigma_{ideal} = \dfrac{0.5}{\sqrt{games}}$ makes sense in sporting events which end in either a win or a loss, but what about sports which can end in a tie game such as hockey or soccer? In sports such as these a trinomial measure is needed to measure the distribution of end of season point totals.

Section 1 develops and analyses a measure of competitive balance for the NHL which extends the standard competitive balance ratio, or the *R* measure, beyond the binomial case to sports leagues in which games can meaningfully end in a draw. Section 2 looks at the effect the size of the talent pool has on the equal distribution of end of season point totals. Section 3 develops the measure for the REL and CRL and compares league parity in the NHL, REL and CRL. Section 4 uses league demographic data and Granger causality to test the effect of a change in talent supply on competitive balance in the NHL, REL and CRL. Section 4 summarizes and concludes.

4.2 Measuring Parity in the NHL

For most (1917-1998) of the NHL's history each game had 3 potential outcomes, a win, a loss and a tie with a point outcome in which a win was worth 2 points, a loss was worth 0 points and a draw worth 1 point. The original scoring system, call it system 1, was changed in 1999 to each game having 4 potential outcomes in which a win is worth 2 points, a loss worth 0, an overtime loss worth 1 and a draw at the end of overtime worth 1 for both teams, call this scoring system 2. The present system, system 3 (2005 – present) returned to 3 potential outcomes but eliminated tie games by ending the overtime period, if tied, with a shootout. Under system 3 a win is worth 2 points, a loss 0 and an overtime loss is worth 1 point. Table 4.1 summarizes these periods for the NHL.

We can, see from Table 4.1 that the change in the scoring systems from System 1 to System 2 reduced the number of tie games. Counting an overtime loss as 1 point instead of in the old system which counted an overtime loss as 0 points could induce players to be satisfied with the 1 point for making it to overtime which if they won in overtime would only increase to 2 points.

Measuring league parity requires that the three different scoring systems listed above be taken into account when measuring a value for an ideally balanced league. Measuring league parity involves computing the variance of end of season point totals.

(i) $$\sigma_{xj}^2 = VAR(X_j) = \sum_{i=1}^{n} p_{ij} \cdot \left(x_i - \mu_{xj}\right)$$

where, p_{ij} is the probability of outcome x_i occurring under the j^{th} scoring system. The expected point outcome for the j^{th} scoring system is then (*ii*).

Table 4.1

NHL percentages of wins, losses, draws and overtime losses

	Time Period	Total Games	% of Games Ending in a win	% of Games Ending in a Loss	% of Games Ending in a Draw	% of Games Ending in a Over Time Loss
System 1:	1917/18-1998/99	67420	42.89%	42.89%	14.22%	0%
System 2:	1999/00-2003/04	12136	43.62%	38.09%	12.84%	5.45%
System 3:	2005/06-2007/08	7380	50.00%	38.70%	0%	11.30%

(*ii*) $$\mu_{xj} = \sum_{i=1}^{n} p_{ij} \cdot x_i$$

We can now calculate the expected point outcome for each scoring system in the NHL. This section will proceed by first calculating probabilities for each game outcome, win, lose or draw then calculating the expected point outcome μ_x under each system. Once the expected point outcomes are calculated, the variance and standard deviation for each period is computed resulting in the equations for the ideal standard deviation of final standing point outcomes.

4.2.1 Scoring System 1. Under system 1 the game ends in either a win a loss or a draw. As noted in the literature review, Cain and Haddock (2006) compute a trinomial measure of league parity using the actual distribution of tie games. The authors find that the case of the English Premier League ties occurred 24.59% of the time with wins and losses occurring 37.705% of the time. Table 4.1 shows that tie games are less likely in the NHL occurring approximately 13.5% of the time on average. It could be assumed, as Cain and Haddock (2006) do, that the historical distribution of game outcomes should play a role in determining what the outcome of any one game would be if both teams had an equal probability of winning, losing or tying. In this paper I will choose not to use history as a guide and assume any one outcome, even tie games, is equally likely. I believe this assumption is more in the spirit of the method developed by Fort (1992) in that the uncertainty of outcome is highest when each outcome has an equal probability of occurring. Assuming equal probability of outcomes we have, (4.1.0), (4.1.1) and (4.1.2).

(4.1.0) $$P_{win} = \frac{1}{3}$$

(4.1.1) $$P_{loss} = \frac{1}{3}$$

(4.1.2) $$P_{draw} = \frac{1}{3}$$

With 2 points for a win, 0 for a loss and 1 for a draw outcome x_1 is then (4.1.3).

(4.1.3) $$x_1 = 2win + draw$$

We can then calculate the expected point outcome as (4.1.4).

(4.1.4) $$\mu_{x1} = 2\left(\frac{1}{3}\right) + 0\left(\frac{1}{3}\right) + 1\left(\frac{1}{3}\right) = \left(\frac{1}{3}\right)(2+0+1) = 1$$

4.2.2 Scoring System 2. Under system 2 a regulation period can end in either a win a loss or a tie, similar to system 1, letting a win occur with $p_{win} = \frac{1}{3}$, a loss occurs with $p_{loss} = \frac{1}{3}$ and ties with $p_{tie} = \frac{1}{3}$. Overtime is the result of a tie at the end of regulation. Therefore in overtime each outcome (overtime win, overtime loss and overtime tie) again occurs with the same probabilities, as though a new game were started in overtime. The probabilities of winning (in overtime or regulation), losing in regulation, losing in overtime and tied at the end of overtime can be calculated as (4.1.5), (4.1.6), (4.1.7) and (4.1.8).

(4.1.5) $$P_{win} = \left(P_{regulationwin}\right) + \left(P_{regulationdraw}\right)\left(P_{overtimewin}\right) = \left(\frac{1}{3}\right) + \left(\frac{1}{3}\right)\left(\frac{1}{3}\right) = \frac{4}{9}$$

(4.1.6) $$P_{loss} = \left(P_{regulationloss}\right) = \frac{1}{3}$$

(4.1.7) $$P_{overtimeloss} = \left(P_{regulationdraw}\right)\left(P_{Loss}\right) = \left(\frac{1}{3}\right)\left(\frac{1}{3}\right) = \frac{1}{9}$$

(4.1.8) $$P_{overtimedraw} = \left(P_{regulationdraw}\right)\left(P_{draw}\right) = \left(\frac{1}{3}\right)\left(\frac{1}{3}\right) = \frac{1}{9}$$

With 2 points for a win, 0 for a loss, 1 point for a draw at the end of overtime and 1 point for the team that loses in overtime the outcome x_2 is then (4.1.9).

(4.1.9) $$x_2 = 2win + OT_{loss} + OT_{draw}$$

The expected point outcome for scoring system 2 is then:

(4.1.10) $$\mu_{x2} = 2\left(\frac{4}{9}\right) + 0\left(\frac{1}{3}\right) + 1\left(\frac{1}{9}\right) + 1\left(\frac{1}{9}\right) = \left(\frac{1}{9}\right)\left(8 + 0 + 1 + 1\right) = \frac{10}{9}$$

4.2.3 Scoring System 3. Under scoring system 3, no games end in a tie but regulation can end in a tie. For regulation the probabilities $\frac{1}{3},\frac{1}{3},\frac{1}{3}$ are used, but when the game goes to overtime, $p_{win} = \frac{1}{2}$ & $p_{loss} = \frac{1}{2}$. The probability of each outcome occurring for system 3 can be calculated as follows in (4.1.11), (4.1.12) and (4.1.13).

(4.1.11) $$P_{win} = \left(P_{regulationwin}\right) + \left(P_{regulationdraw}\right)\left(P_{overtimewin}\right) = \left(\frac{1}{3}\right) + \left(\frac{1}{3}\right)\left(\frac{1}{2}\right) = \frac{1}{2}$$

(4.1.12) $$P_{loss} = \left(P_{regulationloss}\right) = \frac{1}{3}$$

(4.1.13) $$P_{overtimeloss} = \left(P_{regulationdraw}\right)\left(P_{Loss}\right) = \left(\frac{1}{3}\right)\left(\frac{1}{2}\right) = \frac{1}{6}$$

With 2 points for a win, 0 for a loss and 1 point for the team that loses in overtime the outcome x_3 is then (4.1.14).

(4.1.14) $$x_3 = 2win + OT_{loss}$$

The expected point outcome for period 3 is then (4.1.15).

(4.1.15) $$\mu_{x3} = 2\left(\frac{1}{2}\right) + 0\left(\frac{1}{3}\right) + 1\left(\frac{1}{6}\right) = \left(\frac{1}{6}\right)\left(6 + 0 + 1\right) = \frac{7}{6}$$

The next step in the calculation of the ideal standard deviation is to calculate the variance of each well balanced contest for each scoring system which can be done using the calculated expected point outcomes of (4.1.4), (4.1.10) and (4.1.15) as (4.1.16), 4.1.17) and (4.1.18).

(4.1.16) $$\sigma_{x1}^2 = \frac{1}{3}\left((2-1)^2 + (0-1)^2 + (1-1)^2\right) = \frac{2}{3}$$

(4.1.17) $$\sigma_{x2}^2 = \frac{1}{9}\left(\left(2-\left(\frac{10}{9}\right)\right)^2 + \left(0-\left(\frac{10}{9}\right)\right)^2 + \left(1-\left(\frac{10}{9}\right)\right)^2 + \left(1-\left(\frac{10}{9}\right)\right)^2\right) = \frac{166}{729}$$

(4.1.18) $$\sigma_{x3}^2 = \frac{1}{6}\left(\left(2-\frac{7}{6}\right)^2 + \left(0-\frac{7}{6}\right)^2 + \left(1-\frac{7}{6}\right)^2\right) = \frac{25}{72}$$

When such well balanced contests occur over a season of g independent games then the variance, σ_{xj}^2, of the final point total for each j^{th} scoring system is (4.1.19), (4.1.20) and (4.1.21).

(4.1.19) $$\sigma_{x1}^2 = g\frac{2}{3}$$

(4.1.20) $$\sigma_{x2}^2 = g\frac{166}{729}$$

(4.1.21) $$\sigma_{x3}^2 = g\frac{25}{72}$$

This then allows the ideal standard deviation, σ_{idealj}, to be calculated for each j^{th} scoring system as (4.1.22), (4.1.23) and (4.1.24).

(4.1.22) $$\sigma_{ideal1} = \sqrt{\frac{2}{3}g}$$

(4.1.23) $$\sigma_{ideal2} = \sqrt{\frac{166}{729}g}$$

(4.1.24) $$\sigma_{ideal3} = \sqrt{\frac{25}{72}g}$$

Similar to calculating the *R* measure, the distribution of wins in a sports league can be modeled as the deviation of the actual standard deviation of final point outcomes divided by the ideal standard deviation of final point outcomes, where the ideal is no longer binomial and changes depending on the structure of the scoring system.

(*iii*) $$R_t^{adj} = \frac{\sigma_{actual_t}}{\sigma_{idealj}}$$

Where *t* refers to the time period under which competitive balance is being modeled

and $\sigma_{actualj} = \sqrt{\frac{\sum_{i=1}^{N}\left(POINTS_{i,t} - \overline{POINTS_t}\right)^2}{N}}$ refers to the actual standard deviation of points in the league under the j^{th} scoring system, with $POINTS_{i,t}$ being the end of season point total for team *i* in year *t* and *N* being the number of games played by each team over the course of the season.

The adjusted competitive balance ratio, R_t^{adj} can then be calculated for each time period by calculating $\sigma_{actual\,t}$ for each year and then dividing this by $\sigma_{ideal\,j}$ calculated for each scoring system used during year *t*.

(4.1.25) $$R_{1917-98}^{adjNHL} = \frac{\sigma_{actual_t}}{\sqrt{\frac{2}{3}g}}$$

(4.1.26) $$R_{1999-03}^{adjNHL} = \frac{\sigma_{actual_t}}{\sqrt{\frac{166}{729}g}}$$

(4.1.27) $$R_{2005-07}^{adjNHL} = \frac{\sigma_{actual_t}}{\sqrt{\frac{25}{72}g}}$$

Table 4.2 reports the mean value of R_t^{adjNHL} for each of the different scoring systems. From Table 4.2, scoring system 2 produced the lowest level of league parity by reporting the highest R_t^{adjNHL} for any of the time periods. Calculating R_t^{adjNHL} for each year over the 100 year history of the NHL, Figure 4.1, we see that the R_t^{adjNHL} is increasing over the course of NHL history implying a worsening of parity since the leagues inception. The lowest level of league parity occurs under scoring system 2. This could be due to the assumption of balanced probabilities. It could also be due to the structure of the scoring system. Under scoring system 2 a team is awarded a point if they finish tied at the end of overtime or if they lose in over time. It could be the case that the single additional point

Table 4.2

Mean values of R_t^{adjNHL} for the NHL.

Scoring System	Seasons Used	Mean R_t^{adj}	Number of Observations
System 1	1917/18-1998/99	2.44	82
System 2	1999/00-2003/04	3.73	5
System 3	2005/06-2007/08	2.69	3

Notes: The 2004/05 season was not played due to a player strike.

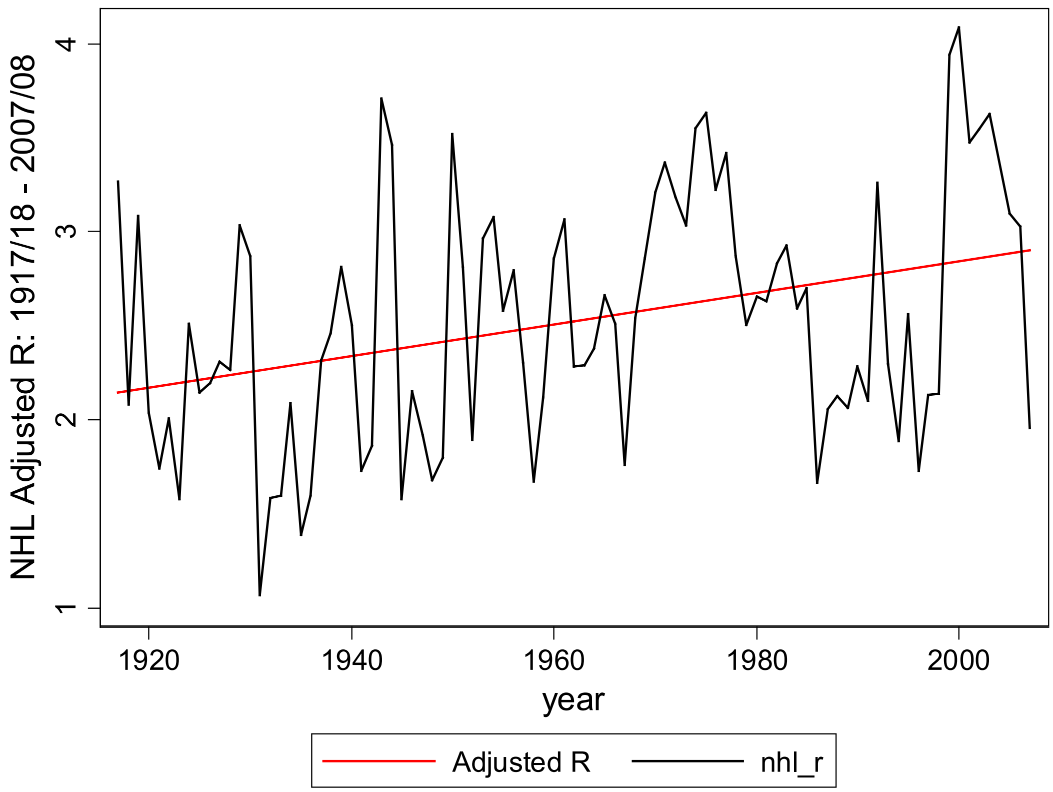

Figure 4.1. Fitted R_t^{adjNHL} for the NHL, 1917/18 to 2000/2008.

earned by winning is an insufficient incentive for players to try harder when without trying hard they are ensured of at least 1 point.

The only other period in the modern era (post 1950) in which league parity was as low as it was under scoring system 2 occurred in the 1970s which had a mean R_t^{adjNHL} of 3.2 (Figure 4.1). The large R_t^{adj} during the 1970s could be explained with talent decompression, the result of the rival World Hockey Association (WHA) from 1972-1977, taking some players who would have been playing in the NHL. In addition to the impact of the WHA, the NHL further decompressed by dramatically expanding the number of teams from 6 teams to 12 teams in 1967/68 then to 14 in 1970/71, 16 in the 1972/73 season and then to 18 in the 1974/75 season. In 2000/01 the league expanded from 28 to 30 teams which, similar to the expansion of the 1970's though less dramatic could, through talent decompression, be responsible for the positive spike in the R_t^{adjNHL} seen in the early 2000s.

If talent supply has an effect on league parity then we should see talent supply and league parity moving in opposite directions. As the number of players from the Czech Republic and Russia increase we would expect, if the "Gould Hypothesis" holds, that R_t^{adjNHL} is decreasing. Furthermore, a league wishing to maximize the uncertainty of outcome would construct policy geared toward this objective. In 1962 the NHL held its first reverse order draft and in 1992 the NHL instituted free agency. Do these policies have an impact on the distribution of wins in the NHL? It is to this question that I now turn.

4.3 OLS Regression of Talent Supply in the NHL

An OLS regression can be used to asses if there is a relationship between talent supply, league policy and league parity in the NHL.

$$R_t^{adjNHL} = \beta_0 + \beta_1 WHA + \beta_2 TEAMS + \beta_3 \%RUSSIAN + \beta_4 \%CZECH/SLOVAK + \beta_5 FREE + \beta_6 DRAFT + \beta_7 SYSTEM_j + \varepsilon_t \quad (4.2.0)$$

where R_t^{adjNHL} covers the 1917/18 season to the 2007/2008 season, WHA is a dummy variable for the rival World Hockey Association which was in existence from 1972-1977, *%RUSSIAN* and *%CZECH/SLOVAK* are the percentage of Russian, Czech and Slovakian players in the NHL in year *t*, *FREE* is a dummy variable = 1 for the years after 1992, *DRAFT* is a dummy = 1 for the years after 1962 and $SYSTEM_j$ is a dummy = 1 for the years in which the j^{th} scoring system was used. Two models are estimated, Model 1 includes the dummy variables for scoring system 2 and scoring system 3 and Model 2 drops the constant to allow for inclusion of the three scoring system dummies.
The results from equation (4.2.0) are reported in Table 4.3.

Looking first at Model 1 we see, consistent with the talent decompression hypothesis, the years of the rival WHA league are positively related with the R_t^{adjNHL} meaning that the distribution of wins in the NHL was more unequal during the years in which it was competing with the WHA for players. The talent supply variables are significant and the two scoring system dummies are insignificant arguing that there is not a significant difference in league parity when the NHL shifted from scoring system 1.

Table 4.3

OLS estimates of equation (4.2.0)

	MODEL 1	MODEL 2
WHA	0.911** (3.19)	0.971** (2.85)
TEAMS	-0.017 (-0.84)	-0.000 0
%RUSSIAN	0.128 (1.21)	0.139 (1.11)
%CZECH/SLOVAK	0.033 (0.28)	0.086 (0.62)
FREE-AGENCY	-0.973 (-1.62)	-1.152 (-1.62)
DRAFT	0.332 (1.35)	0.151 (0.52)
SYSTEM-1 *(1917-1998)*		2.206** (12.0)
SYSTEM-2 *(1999-2003)*	1.233 (1.86)	2.800** (3.63)
SYSTEM-3 *(2005-2007)*	0.594 (0.92)	2.296** (3.00)
Constant	2.395** (15.34)	
Observations	90	90
R-squared	0.33	0.94

Notes: *t*-statistics in parentheses. ** represents significance at the 5% level.

In Model 2, when running the regression through the origin, the WHA variable is still significantly positive. Again the talent supply variables are not significant but the scoring system dummies are. When running the regression through the origin we would expect the scoring system dummies to be significantly different from 0 since the R_t^{adj} measure approaches 1 from above. Furthermore, the large R-squared is to be expected when forcing a regression through the origin and cannot be interpreted in any meaningful way.

What do Models 1 and 2 tell us about the impact of talent compression and/or decompression on league parity? In both models, the decompressing impact of the WHA has corresponded with a period of an unequal distribution of end of season point totals which allows us to say the obvious result that rival leagues are bad for business. The uncertain outcome of any game is reduced when talent is distributed between two leagues. The talent pool variables are not having an impact on league parity. The sign of the insignificance of the free agency variable is consistent with the accepted wisdom, Rottenberg (1956) argued that free agency would be ineffective while team owners argued that it would negatively affect the equal distribution of wins. Rodney Fort (2011) sums up the sides:

> The invariance principal predicts that competitive balance is the same whether the talent market is competitive or governed by the reserve clause. If the league is imbalanced to start with, it will be equally imbalanced in either case. This is directly opposite of what owners predicted would happen. (p. 261)

This discussion is primarily concerned with talent supply effects and it seems that in the case of expanding the size of the talent pool the level of league parity was not effected to any significant degree. While consistent with Zimbalist, talent decompression, as we see with the WHA, seems to correspond to periods of less equal distribution of wins. The question still remains about causality in the case of Russian and Czech and Slovak players. The next section addresses this question.

4.4 Measuring Parity in the REL and CRL

Estimation of equation (4.2.0) provides some evidence of a link between the supply of talented athletes and parity within that league. Further analysis of other leagues could be informative to try and assess if there is a one way relationship between league parity and talent supply. Turning next to league parity in the REL and CRL we again see three different scoring systems. The first system is identical to that of system 1 in the NHL where a win is worth 2 points a loss 0 points and a tie worth 1 point. This system was used in the REL from the 1978/79 season to the 1998/99 season and the CRL from 1987/88 to 2000/01. To analyze competitive balance in the REL and CRL two additional scoring systems, system 4 and system 5, will have to be calculated. System 4 counts a regulation win as 3 points, an overtime win is worth 2 while an overtime loss or an overtime tie are both worth 1 while a regulation loss is worth 0 points. System 4 was adopted in the REL from the 1999/00 season to the 2005/06 season and from the 2001/02 season to the 2005/06 in the CRL. System 5, used from the 2006/07 season to present in both the REL and the CRL eliminates tie games with a shootout and counts a regulation win as 3 points, an overtime win is worth 2 points and an overtime loss is worth 1 point and as usual a regulation loss is worth 0 points. Table 4.4 and Table 4.5 report the mean percentage of each outcome occurring under the 3 different systems.

Table 4.4

REL, CRL percentages of wins, losses and ties

REL	Time Period	Total Games	% of Games Ending in a win	% of Games Ending in a Loss	% of Games Ending in a Draw
System 1	1978/79-1998/99	15547	43.22%	43.22%	13.6%
CRL					
System 1	1987/88-2000/01	8675	41.61%	41.61%	16.77%

Notes: Prior to 1994 the CRL was known as the Czechoslovakia League.

Table 4.5

REL, CRL percentages of wins, losses, overtime wins, overtime losses and ties

REL	Time Period	Total Games	% of Games Ending in a Regulation Win	% of Games Ending in an Overtime Win	% of Games Ending in a Regulation Loss	% of Games Ending in an Overtime Loss	% of Games Ending in a Draw
System 4	1999/00-2005/06	7294	39.8%	3.81%	39.8%	3.81%	12.78%
System 5	2006/07-2009/10	4968	39.63%	10.35%	39.63%	10.35%	0
CRL							
System 4	2001/02-2005/06	3628	39.83%	5.13%	39.83%	5.13%	10.10%
System 5	2006/07-2009/10	2912	38.67%	11.33%	38.67%	11.33%	0

Notes: In 2008/09 the REL became the Kontinental League.

Table 4.4 shows that a game ending in a draw is more likely in the CRL than in the REL and the NHL (Table 4.1). If it is considered that a draw is evidence of two evenly matched teams then the high percentage of draws in the CRL could be some indication that parity in the CRL is higher than in the REL and the NHL during the time when scoring system 1 was implemented in all three leagues. Table 4.5 shows that once the two leagues switched to scoring system 4, the percentage of draw games was higher in the REL compared to the CRL. Scoring system 4 in the REL and CRL is similar to that of system 2 in the NHL, which under this system experienced draw games 12.84% of the time which now exceeds that of the REL and CRL. The scoring system used in the REL from1978/79-1998/99 and the CRL from 1987/88-2000/01 is identical to scoring system 1 used in the NHL from 1917 to 1998 while the later systems require further computation. Being the same as equation (5.0), $R_{1978-98}^{adjREL}$ and $R_{1987-00}^{adjCRL}$ can be written as (4.3.0) and (4.3.1).

(4.3.0) $$R_{1978-98}^{adjREL} = \frac{\sigma_{actual_t}}{\sqrt{\frac{2}{3}g}}$$

(4.3.1) $$R_{1987-00}^{adjCRL} = \frac{\sigma_{actual_t}}{\sqrt{\frac{2}{3}g}}$$

4.4.1 Scoring System 4. Under system 4, in place in the REL from 1999/00 to 2005/06 and in the CRL from 2001/02 to 2005/06, a regulation period can end in either a win a loss or a draw, similar to system 1, each of these three outcomes occur with a 1/3 probability. Unlike in the NHL, winning in overtime is worth less, 2 points than winning in regulation, 3 points resulting in the need to calculate the probability of an overtime win. The probabilities of each outcome occurring can be calculated as (4.3.4), (4.3.5), (4.3.6), (4.3.7) and (4.3.8).

(4.3.4) $$P_{regulationwin} = \frac{1}{3}$$

(4.3.5) $$P_{regulationloss} = \frac{1}{3}$$

(4.3.6) $$P_{OTwin} = (P_{draw})(P_{win}) = \frac{1}{9}$$

(4.3.7) $$P_{overtimeloss} = (P_{regulationdraw})(P_{Loss}) = \left(\frac{1}{3}\right)\left(\frac{1}{3}\right) = \frac{1}{9}$$

(4.3.8) $$P_{overtimedraw} = (P_{regulationdraw})(P_{draw}) = \left(\frac{1}{3}\right)\left(\frac{1}{3}\right) = \frac{1}{9}$$

with 3 points for a win, 2 points for an overtime win, 0 for a loss, 1 point for the team that loses in overtime and 1 point for both teams if overtime ends in a draw the outcome x_4 is then (4.3.9).

(4.3.9) $$x_4 = 3win + 2OT_{win} + OT_{loss} + OT_{draw}$$

This yields the expected point outcome for system 4, (4.3.10).

(4.3.10) $$\mu_{x4} = 3\left(\frac{1}{3}\right) + 0\left(\frac{1}{3}\right) + 1\left(\frac{1}{9}\right) + 1\left(\frac{1}{9}\right) + 1\left(\frac{1}{9}\right) = \left(\frac{1}{9}\right)(9 + 0 + 1 + 1) = \frac{11}{9}$$

With a variance, (4.3.11).

(4.3.11) $$\sigma_{x4}^2 = \frac{1}{9}\left(\begin{array}{l} \left(3 - \left(\frac{11}{9}\right)\right)^2 + \left(0 - \left(\frac{11}{9}\right)\right)^2 + \left(1 - \left(\frac{11}{9}\right)\right)^2 \\ + \left(1 - \left(\frac{11}{9}\right)\right)^2 + \left(1 - \left(\frac{11}{9}\right)\right)^2 \end{array}\right) = \frac{389}{729}$$

The ideal standard deviation for scoring system 4 is then (4.3.12).

(4.3.12) $$\sigma_{x4} = \sqrt{\frac{389}{729} g} \quad (10.8)$$

For the two leagues, the REL and CRL, the R_t^{adj} for scoring system 4 can then be calculated by computing:

(4.3.13) $$R_{1999-05}^{adjREL} = \frac{\sigma_{actual_t}}{\sqrt{\frac{389}{729} g}}$$

(4.3.14) $$R_{2001-05}^{adjCRL} = \frac{\sigma_{actual_t}}{\sqrt{\frac{389}{729} g}}$$

4.4.2 Scoring System 5. Finally, scoring system 5 eliminates tie games by employing a shootout at the end of the overtime period but maintains a reduced point total for winning in overtime as opposed to winning in regulation. The probability of each outcome occurring under system 5 are shown in (4.3.15), (4.3.16), (4.3.17) and (4.3.18).

(4.3.15) $$P_{regulationwin} = \frac{1}{3}$$

(4.3.16) $$P_{regulationloss} = \frac{1}{3}$$

(4.3.17) $$P_{OTwin} = (P_{tie})(P_{win}) = \left(\frac{1}{3}\right)\left(\frac{1}{2}\right) = \frac{1}{6}$$

(4.3.18) $$P_{OTloss} = (P_{tie})(P_{loss}) = \left(\frac{1}{3}\right)\left(\frac{1}{2}\right) = \frac{1}{6}$$

The final standing point outcome is given by (4.3.19).

(4.3.19) $$x_5 = 3win + 2OTwin + OTloss$$

This yields the expected point outcome for scoring system 5 is (4.3.20).

(4.3.20) $$\mu_{x5} = 3\left(\frac{1}{3}\right) + 0\left(\frac{1}{3}\right) + 2\left(\frac{1}{6}\right) + 1\left(\frac{1}{6}\right) = \left(\frac{1}{6}\right)(6 + 2 + 1) = \frac{9}{6} = \frac{3}{2}$$

With a variance, (4.3.21).

(4.3.21) $$\sigma_{x5}^2 = \frac{1}{6}\left(\left(3-\left(\frac{9}{6}\right)\right)^2 + \left(0-\left(\frac{9}{6}\right)\right)^2 + \left(2-\left(\frac{9}{6}\right)\right)^2 + \left(1-\left(\frac{9}{6}\right)\right)^2\right) = \frac{5}{6}$$

The ideal standard deviation for scoring system 5 is then (4.3.22).

(4.3.22) $$\sigma_{x5} = \sqrt{\frac{5}{6}g}$$

For the two leagues, the REL and CRL, the R_t^{adj} for scoring system 5 can then be calculated by computing (4.3.23) and (4.3.24).

(4.3.23) $$R_{2006-09}^{adjREL} = \frac{\sigma_{actual_t}}{\sqrt{\frac{5}{6}g}}$$

(4.3.24) $$R_{2006-09}^{adjCRL} = \frac{\sigma_{actual_t}}{\sqrt{\frac{5}{6}g}}$$

Table 4.6 reports the mean values $R^{adjREL}_{1978-2009}$ and $R^{adjCZECH}_{1987-09}$ for each of the different scoring systems. Over the history of the two leagues, the CRL has been significantly[2] more balanced than the REL. In both leagues parity under scoring system 4 yielded significantly[3] worse parity than any of the other scoring systems. Figure 4.2 graphs yearly values of $R^{adjREL}_{1978-2009}$ and $R^{adjCZECH}_{1987-09}$. Similar to the NHL league parity has been worsening on average and the early 1990s appear to be a time of generally decreasing parity. Talent decompression in the two leagues could be playing a role as more Czech and Russian players emigrated to the NHL.

Finally, Table 4.7 shows the mean values of R^{adj}_t for all three leagues. The REL has the highest average R^{adj}_t for the three leagues with the NHL second and the CRL coming in at third. The next section will use Granger causality to test for a causal relationship between talent supply and league parity.

4.5 Granger Causality and the Direction of Talent Supply Effects

Using R^{adj}_t as a measure of parity we can now test the hypothesis that parity is affected by the size of the talent pool. If an increase in talent supply improves parity between teams then we should see a decrease in the R^{adj}_t measure in the NHL (i.e., more parity) and an increase in the REL and CRL (i.e., less parity) due to the emigration of talented hockey players from Russia and the Czech Republic to the NHL.

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[2] A *t*-test on the means of $R^{adjREL}_{1978-2009}$ and $R^{adjCZECH}_{1987-09}$ yields t = 4.60.

[3] t = 3.13 for the REL and 3.35 for the CRL.

Table 4.6

Mean values of R_t^{adj} for the REL and CRL

Scoring System	Seasons Used	Mean R_t^{adj}	Number of Observations
REL			
System 1	1978/79-1998/99	3.08	21
System 4	1999/00-2005/06	4.33	7
System 5	2006/07-2009/10	3.08	4
All Years	1978/79-2009/10	3.36	32
CRL			
System 1	1987/88-2000/01	2.00	14
System 4	2001/02-2005/06	3.66	5
System 5	2006/07-2009/10	2.12	4
All Years	1987/88-2009/10	2.38	23

Notes: Final standing points totals from HockeyDB.com. During the 1980s, the REL employed a relegation system in which four teams were relegated midway through the season, subsequently within a season the number of games played for these four teams is less than that of the non-relegated teams. To handle this complication the number of games played in a REL season is averaged.

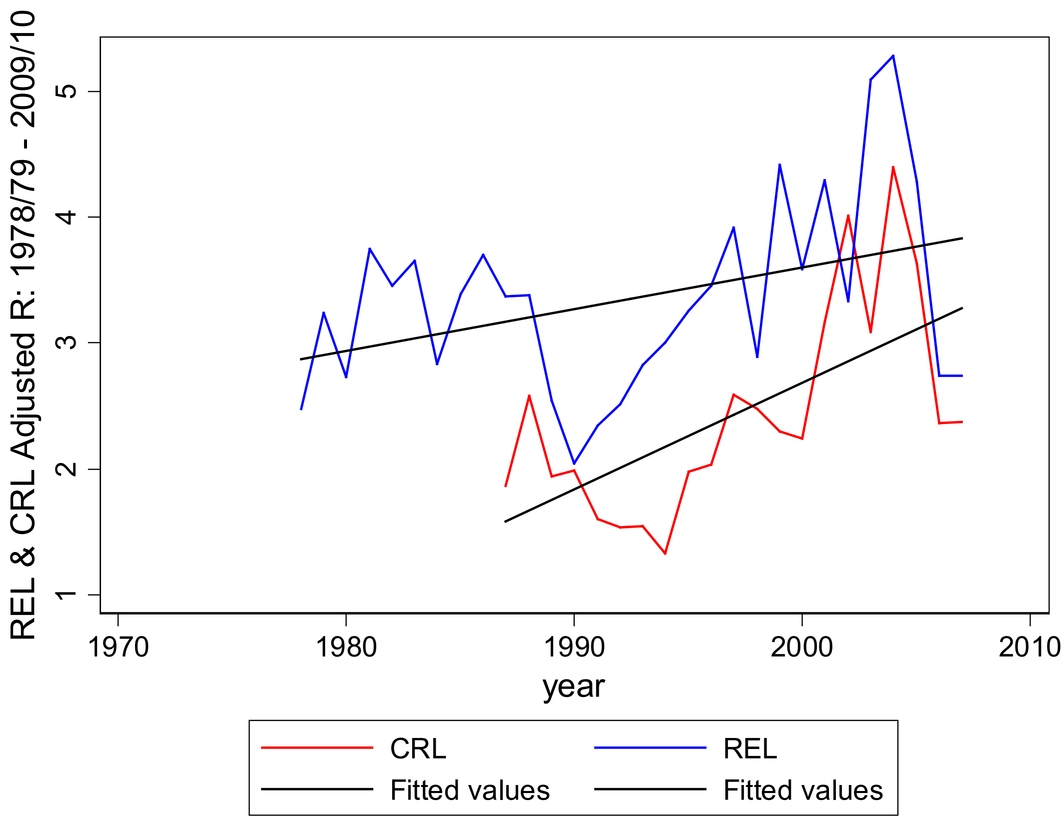

Figure 4.2: Fitted values of $R^{adjREL}_{1978-2009}$ and $R^{adjCZECH}_{1987-09}$.

Table 4.7

Average R_t^{adj} for the NHL, REL and CRL

League	Label	Years	Number of Observations	Average Level of Competitive Balance
Russian Elite League	REL	1978/79-2009/10	32	3.36
National Hockey League	NHL	1970/71-2007/08	37	2.80
National Hockey League	NHL	1917/18-2007/08	90	2.52
Czech Republic League	CRL	1987/88-2009/10	23	2.38

Following Granger (1969) we can test the direction of causality for a two-variable model with the two equations in (*iv*):

(iv)

$$X_t = \sum_{j=1}^{m} \alpha_j X_{t-j} + \sum_{j=1}^{m} \beta_j Y_{t-j} + \varepsilon_t$$
$$Y_t = \sum_{j=1}^{m} \rho_j X_{t-j} + \sum_{j=1}^{m} \delta_j Y_{t-j} + \varepsilon_t$$

It can then be said that Y_t is Granger causing X_t if β_j is significantly different from zero and X_t is Granger causing Y_t if ρ_j is significantly different from zero (Granger, 1969). If both cases occur then the system is said to be a feedback system while a direction of causality is implied when either one or the other occurs, for instance if β_j is significantly different from zero and ρ_j is not then the direction of causality is implied to run from Y_t to X_t and not from X_t to Y_t.[4]

To test whether or not talent supply Granger causes league parity in the NHL the following systems of equations, (4.4.0), (4.4.1) and (4.4.2) will be estimated.

(4.4.0)

$$NON\_NA_t = \beta_0 + \alpha_1 NON\_NA_{t-1} + \beta_2 R_{t-1}^{adjNHL} + e_{it}$$
$$R_t^{adjNHL} = \beta_0 + \rho_1 NON\_NA_{t-1} + \delta_2 R_{t-1}^{adjNHL} + e_{it}$$

where R_t^{adjNHL} is the measure of competitive balance computed for the NHL for the years 1917 to 2008. Talent supply changes in the NHL are now measured using the total

[4] Green notes that one can infer Granger Causality "when lagged values of a variable, say x_t, have explanatory power in a regression of a variable y_t on lagged values of y_t and x_t" (Green, 2003, p. 592).

number of players playing NHL and who were born outside Canada or the United States in the NHL in year *t*, NON_NA_t as opposed to the use of percentage of players in the previous study. We would expect that if an increase in the size of the talent pool Granger caused an increase in league parity then ρ_1 should be negative and significant.

To test for a reduction in league parity due to talent decompression, the focus will be on Russian and Czechoslovakian players leaving their respective home countries. Talent decompression will be measured using the total number of players playing in the NHL in year *t* and who were born in Russia or Czechoslovakia, RUS_t and $Czech_t$ respectively. These would be professional players who would have potentially played in a league in their home country, but emigrated out of their home country, Russia or Czechoslovakia, to play in the NHL. The variable $Czech_t$ includes players, who after 1993, were born in Slovakia and players born in the Czech Republic. League parity will be measured using the computed measure of competition, R_t^{adjREL} and R_t^{adjCRL}, for the REL and CRL respectively. The two systems of equations for the REL and CRL are then (4.4.1) and (4.4.2).

$$\begin{aligned} RUS_t &= \beta_0 + \alpha_1 RUS_{t-1} + \beta_2 R_{t-1}^{adjREL} + e_{it} \\ R_t^{adjREL} &= \beta_0 + \rho_1 RUS_{t-1} + \delta_2 R_{t-1}^{adjREL} + e_{it} \end{aligned} \tag{4.4.1}$$

$$\begin{aligned} CZECH_t &= \beta_0 + \alpha_1 CZECH_{t-1} + \beta_2 R_{t-1}^{adjCRL} + e_{it} \\ R_t^{adjCRL} &= \beta_0 + \rho_1 CZECH_{t-1} + \delta_2 R_{t-1}^{adjCRL} + e_{it} \end{aligned} \tag{4.4.2}$$

In equations, (4.4.1) and (4.4.2), if talent decompression Granger causes a decrease in league parity then ρ_1 should be positive and significant. A necessary condition for Granger causality is that the variables involved be stationary. Table 4.8 reports the results of testing for a unit root of the relevant variables using an augmented Dickey Fuller test. Looking at Table 4.8 we see that many of the variables are nonstationary (taking significantly different from zero at the 5% level to indicate stationarity), but when first differenced become stationary, suggesting an integration of order one[5] for the variables: R_t^{adjCRL}, $NON\text{-}NA_t$, RUS_t, $CZECH_t$. Before testing for Granger causality, the nonstationary variables are first differenced (denoted with Δ) resulting in the following 3 systems of two equations, (4.4.3), (4.4.4) and (4.4.5).

(4.4.3)
$$\Delta NON\_NA_t = \beta_0 + \alpha_1 \Delta NON\_NA_{t-1} + \beta_2 R_{t-1}^{adjNHL} + e_{it}$$
$$R_t^{adjNHL} = \beta_0 + \rho_1 \Delta NON\_NA_{t-1} + \delta_2 R_{t-1}^{adjNHL} + e_{it}$$

(4.4.4)
$$\Delta RUS_t = \beta_0 + \alpha_1 \Delta RUS_{t-1} + \beta_2 R_{t-1}^{adjREL} + e_{it}$$
$$R_t^{adjREL} = \beta_0 + \rho_1 \Delta RUS_{t-1} + \delta_2 R_{t-1}^{adjREL} + e_{it}$$

(4.4.5)
$$\Delta CZECH_t = \beta_0 + \alpha_1 \Delta CZECH_{t-1} + \beta_2 \Delta R_{t-1}^{adjCRL} + e_{it}$$
$$\Delta R_t^{adjCRL} = \beta_0 + \rho_1 \Delta CZECH_{t-1} + \delta_2 \Delta R_{t-1}^{adjCRL} + e_{it}$$

The results of the regressions in (4.4.3), (4.4.4) and (4.4.5) are reported in Table 4.9. For the purposes of this paper, the significance of the coefficient ρ_1 is of primary interest and in all cases this coefficient is insignificant at the 5% level indicating that changes in the talent supply, be they increases in the talent supply, ΔNON_NA_{t-1} or decreases in the talent supply, ΔRUS_{t-1} or ΔRUS_{t-1}, do not Granger cause levels of league parity in the case of the NHL, REL or CRL.

[5] See Green, 2003.

Table 4.8

Augmented Dickey-Fuller tests

	ADF Statistic		ADF Statistic
R_t^{adjNHL} ***	-5.453	NON_NA_t	0.475
ΔR^{adjNHL} ***	-11.589	ΔNON_NA***	-5.184
R_t^{adjCRL}	-2.054	CZECH	1.052
ΔR^{adjCRL} ***	-5.0804	ΔCZECH ***	-7.220
R_t^{adjREL} **	-3.34	RUS	-0.420
ΔR^{adjREL} ***	-7.761	ΔRUS ***	-5.004

Notes: *,**,*** represent significance at the 90%, 95% and 99% critical levels respectively.

Table 4.9

Coefficients β_2 and ρ_1, testing for Ganger Causality

Dependant variable	Coefficient for β_2	Coefficient for ρ_1	Observations
ΔNON_NA	-1.99 (-1.3)		86
R_t^{adjNHL}		0.011 (1.88)	86
ΔRUS	-3.73** (-2.16)		28
R_t^{adjREL}		-0.01 (-0.7)	28
ΔCZECH	-2.76 (-0.57)		16
ΔR^{adjCRL}		0.02 (1.16)	16

Notes: ** indicates significance at the 5% level.

There is a significant result on the β_2 coefficient for the REL. It appears to be the case that changes in league parity in the REL Granger cause changes in the emigration patterns of Russian players to the NHL. In this case, as R_{t-1}^{adjREL} increases (i.e., as the league becomes less competitive), the number of Russian players entering the NHL declines or as the league becomes more competitive the number of Russian players entering the NHL increases. Looking at Figure 4.2 there has been a decrease in the level of competition in the REL since the late 1970s, so as the REL becomes less competitive the change in the number of Russian players playing in the REL is Granger caused to decline. It could be the case that as Russia experienced economic turmoil in the wake of the collapse of communism, which corresponds with the time frame of worsening parity, Russia was producing fewer potential professional hockey players. When one is struggling economically, the luxury of participating in sports would be expected to decline thereby causing the pool of talented Russian players to shrink.

4.6 Conclusion

The adjusted competitive balance ratio, R_t^{adj}, extends the standard deviation ratio to handle leagues which count the game outcome of a draw in end of season point totals. The calculated R_t^{adj}'s for the National Hockey League, the Russian Elite League and the Czech Republic League demonstrate a trend toward worsening parity in each league over the leagues' history. Parity in the NHL was at its worst during the 1970s and early 2000s. The 1970s corresponds to the time frame in which the World Hockey Association was competing with the NHL for talented hockey players, decompressing the talent supply. As demonstrated in Table (4.2) the WHA variable was positive and significant consistent with talent decompression reducing league parity.

The cause of the low levels of league parity in the NHL in the early 2000s is still indeterminate. With free agency established in 1992, two different scoring systems and a relative decrease in the percentage of NHL players born outside of North America there are many potential drivers. The "Gould Hypothesis" would suggest that the increasing percentage of foreign born players would have driven down the adjusted *R* measure of competitive balance and through talent decompression the relative decrease in the percentage of foreign born players after 2000 would have driven up the adjusted R. If talent supply has an effect on league parity then the coefficient estimates of the percentage of Russian and Czechoslovakian players should have been negatively related to the adjusted R. To test for a causal relationship going from talent supply to league parity, Granger Causality testing is employed. If talent compression/decompression Granger causes R_t^{adj} then there would be a significant causal relationship and if this causality were negative it could be argued that increasing the size of the talent pool was acting to increase league parity, but this does not appear to be the case.

The results of this research are that talent decompression could reduce league parity, like we saw with the WHA. It is possible that the talent supply needs to be diffused by a fairly large amount for it to have a significant affect. We see large scale decompression in the case of rival leagues, for example we would expect that league parity in the NFL would be relatively lower between 1960 and 1969 and 1983 to 1987 due to the rival American Football League (before the merger) and the rival United States Football League, respectively. The results concerning the "Gould Hypothesis" and the talent compressing effects on league parity are inconclusive. Insignificant results of Granger Causality testing argue that there is no significant effect of talent supply on league parity. The "Gould Hypothesis" is not confirmed.

CHAPTER 5

VENUS VERSUS SERENA: A GENERALIZED PERFORMANCE ENHANCING DRUG GAME IN TWO ACTS

5.1 Introduction

In this chapter I will develop the Performance Enhancing Drug Game in Haugan (2002), but where Haugan assumes the payoff to the loser is zero when the certainty of the doped athlete winning is equal to 1, I suggest a generalization by adding in a payoff to the loser that can be acquired if the doped athlete is caught and disqualified. I will further develop the game into a four-player, two-stage tournament style game such as can be found in tennis tournaments to analyze how athlete strategies change when an athlete has a lower probability of winning the final game since she has to win both the first game and the second game and has a higher probability of being caught doping since she will have a probability of being caught in the first game and the second game. The multistage tournament format will be used to compare the incentive effects of differing reward schemes, comparing the highly nonlinear reward scheme seen in professional tennis tournaments with the more evenly distributed reward scheme seen in NASCAR.

Section 1 establishes the rules of the game. Section 2 and 3 determine pure strategy Nash Equilibrium conditions for the final and semifinal matches. Section 4 determines pure strategy Nash equilibrium conditions for the tournament game. Section 5 discusses and Section 6 concludes.

5.2 The Tournament Game

The Tournament Performance Enhancing Drug game will follow from the basic assumptions outlined in Haugan (2004).

- Two athletes (of equal strength) compete against each other in some sports event.
- The athletes' possible strategic choices are to use or not use dope. Hence, we assume only one available drug.
- The drug is assumed effective-that is, if one agent takes the drug and the other does not, the "drug taker" wins the competition with certainty. The drug is also assumed to have an equal effect on both athletes. That is, if both athletes take the drug then they are equal in strength.
- Both agents must decide (simultaneously) before the competition to take the drug.
- These decisions are not repeated. Hence we define a "one-shot" simultaneous game.
- The agents' payoffs are defined according to three interesting outcomes for each agent.
    - W: Agent *i* wins the competition.
    - L: Agent *i* loses the competition.
    - E: Agent *i* is exposed as a drug abuser.

    (Haugan, 2004, pp. 70-71)

The Tournament game makes these basic assumptions of Haugan then further extends the game to four players playing in a tournament, whereby all four players compete in two, one-on-one Qualifyings Rounds, each player plays only one game and the winners of the Qualifying Rounds go on to the Finals' Round while the losers in the Qualifying Round go on to the Losers' Round.[1] There are no prizes awarded at the end of the Qualifying Rounds; the tournament prizes are awarded at the end of the Finals' Round and the Losers' Round. The Finals' Round winner receives the first place prize of A, and the Finals' Round loser receives the second place prize B. The Losers' Round winner receives the third place prize D, and the Losers' Round loser receives the fourth place prize of F. It is also assumed that the drugs are banned by the sporting organization and if a player is caught using the drugs she will be fined at a value of C, $C > 0$ and she has a probability of getting caught equal to r.

The prizes and fine for being caught doping can be represented as multiples of the first place prize, let $aA=A$, $bA=B$, $dA=D$ and $fA=A$, where $a=1>b>d>f$ and $cA=C$ where $c > 0$. Even though, $a = 1$ in all cases, the author believes maintaining the notation allows for a more straight forward exposition of the expected payouts. Parameterizing the payouts allows for ready substitution of any particular reward scheme and in the case of the cost of doping, parameterization enhances the realism of the game, in that in most sporting organizations, the penalty for doping is usually a suspension without pay as opposed to a flat cost of some amount for all athletes. This becomes particularly relevant in sports where salaries are not very evenly distributed. For example Los Angeles

[1] Vince Lombardi famously said, "There is only one place in my game, and that's first place. I have finished second twice in my time at Green Bay, and I don't ever want to finish second again. There is a second place bowl game, but it is a game for losers played by losers" (1-Famous-Quotes.com).

Dodgers star hitter Manny Ramirez was suspended for 50 games in 2009 for violating league drug policies, Manny's contract was for \$45 million over 2 years or \$22.5 million per season which works out about \$138,888 per game which means his suspension cost him \$6.9 million (=\$138,888x50). Contrast this with Sergio Mitre, a pitcher for the Yankees who has a salary of \$850,000 for the 2010 season and was also suspended for 50 games. Sergio's cost of doping was \$5,247 per game for a total of \$262,346 (=\$5,247x50). It would probably be considered excessive to fine Sergio \$6.9 million and it would probably be ineffective to fine Manny \$264,346. On the other hand if the cost of doping were pegged to the player's prize (as it is with a suspension without pay where, $cA=C$) then we could say that MLB thinks that a 31% loss in salary (=.31=\$6.9million/\$22.5million for Manny and .31=\$262,346/\$850,000 for Sergio) is a sufficient[2] fine to establish a doping disincentive.

Analysis of the Performance Enhancing Drug Tournament Game will be developed by beginning with the Finals' Round and Losers' Round to establish the expected payouts for the Qualifying Rounds.

5.3 The Finals'

The analysis begins with the Final Round and the expected payouts for given player strategies are as follows.

{ND, ND}: If each player chooses *not-dope,* (ND) then each player has an equal probability of winning the tournament and receiving the first place prize of aA. In

[2] Apparently it was not sufficient for either of these guys, but that is beside the point.

addition each player has an equal probability of obtaining second place and receiving the 2nd place prize. The expected payoffs if both players choose ND are then (P1).

(P1) $$\{ND, ND\}: \left\{ \left(\frac{(a+b)A}{2}\right), \left(\frac{(a+b)A}{2}\right) \right\}$$

{D, ND}: If player 1 chooses *dope*, (D) while player 2 chooses not to dope then player 1 will win with certainty and receive the first place prize of *a*A but also has the chance, *r* of being caught and fined *cA*, resulting in an expected payoff: $aA - rcA = (a - rc)A$. If player 1 chooses *dope* while player 2 chooses *not-dope* then player 2 will win the second place prize *bA* with certainty and has no probability of being caught[3] doping. In addition there is the off chance[4], *r*, that player 1 will be caught *doping* and subsequently disqualified, thus player 2 has a probability *r* of obtaining the winning payoff *aA*. If it is assumed that the match outcome and test outcome are independent then athlete 2's expected payoff if athlete 1 chooses to *dope* is then $bA + raA = (b + ra)A$. The expected payoffs if one player chooses D and the other chooses ND are then (P2).

(P2) $$\{D, ND\}: \{ (a - rc)A, (b + ra)A \}$$

[3] This is assuming no false positives occur. An extension could be to include false positives to the nondoper.

[4] This may not happen all that often but it does happen. For example, the second place rider Oscar Pereiro won the 2006 Tour de France due to the disqualification of Floyd Landis. One way to think about this with team sports, for example, would be the first string player is suspended for some number of games allowing the second string player the opportunity to show her skills.

{D,D}: If both players choose *dope* then they each have a 0.5 probability of winning aA or a 0.5 probability of getting 2nd place and getting bA only if they are both not caught which happens with a probability of $(1\text{-}r)^2$ resulting in an expected monetary payoff: $\frac{A(a+b)(1-r)^2}{2}$. It could also be the case that one player is caught while the other is not which happens with a $(1\text{-}r)r$ probability and expected monetary payoff to the player that is not caught: $aA(1\text{-}r)r$. On the other hand, it could also be the case that the doped player is caught while the other is not resulting in an expected monetary loss to the player caught: - $cA(1\text{-}r)r$. Both players are caught with probability r^2 and expected monetary loss: -cAr^2. The expected payouts if both players choose D are then (P3).

(P3) {D,D}:

$$\begin{bmatrix} \left(\frac{A(a+b)(1-r)^2}{2}+aA(1-r)r-cA(1-r)r-cAr^2\right), \\ \left(\frac{A(a+b)(1-r)^2}{2}+aA(1-r)r-cA(1-r)r-cAr^2\right) \end{bmatrix} \Rightarrow \begin{bmatrix} A\left(\frac{(a+b)(1-r^2)}{2}+ar(1-r)-cr\right), \\ A\left(\frac{(a+b)(1-r^2)}{2}+ar(1-r)-cr\right) \end{bmatrix}$$

The Final Round of the Tournament performance enhancing drug game is represented by the 2x2 matrix in Figure 5.1.

		Player 2	
		D	ND
Player 1	D	$\left[A\left(\frac{(a+b)(1-r^2)}{2}+ar(1-r)-cr\right), A\left(\frac{(a+b)(1-r^2)}{2}+ar(1-r)-cr\right)\right]$	$(b+ra)A,(a-rc)A$
	ND	$(a-rc)A,(b+ra)A$	$\left(\frac{(a+b)A}{2}\right),\left(\frac{(a+b)A}{2}\right)$

Figure 5.1: The Finals' game matrix.
Notes: Using the payoff convention (column, row).

The dominant strategy[5] for a player in the Finals' Round will be determined by the relationships expressed in (5.1.0) and (5.1.1).

(5.1.0) $$(b+ra)A : A\left(\frac{(a+b)(1-r^2)}{2}+ar(1-r)-cr\right)$$

(5.1.1) $$\left(\frac{(a+b)A}{2}\right) : (a-rc)A$$

If

(5.1.2) $$\left[(b+ra)A < A\left(\frac{(a+b)(1-r^2)}{2}+ar(1-r)-cr\right)\right] \& \left[\left(\frac{(a+b)A}{2}\right) < (a-rc)A\right]$$

Then the strictly dominant strategy for player *i* will be (D) and with symmetric payouts, the strictly dominant strategy for all players will be (D) and there will be a Nash equilibrium at {D, D}.

On the other hand, if

(5.1.3) $$\left[(b+rc)A > A\left(\frac{(a+b)(1-r^2)}{2}+ar(1-r)-cr\right)\right] \& \left[\left(\frac{(a+b)A}{2}\right) > (a-rc)A\right]$$

[5] The dominant is defined according to Mas-Colell, Whinston and Green (1995), in definition 8.B.1. "Definition 8.B.1: A strategy $s_i \in S_i$ is a strictly dominant strategy for player i in game $\Gamma N = [I, \{S_i\}, \{u_i(\bullet)\}]$ if for all $s_i^{'} \neq s_i$, we have

$$u_i(s_i, s_{-i}) > u_i(s_i^{'}, s_{-i})$$

For all $s_{-i} \in S_{-i}$."

Then the strictly dominant strategy for player *i* will be (ND) and with symmetric payouts, the strictly dominant strategy for all players will be (ND) and there will be a Nash equilibrium at {ND, ND}.

The dominant pure strategies depend on the expected cost of doping (rc) and the value of the prizes. The pure strategy regions can be established by plotting the relationships in (5.1.0) and (5.1.1) on the (r,c) plane. Setting the two sides of (5.1.0) equal and solving for c.

(5.1.4) $$c = \left(\frac{a(1-3r^2)}{2r}\right) - \left(\frac{b(1+r^2)}{2r}\right)$$

Setting the two sides of (5.1.1) equal and solving for c.

(5.1.5) $$c = \left(\frac{a}{2r}\right) - \left(\frac{b}{2r}\right)$$

Noting that,

(5.1.6) $$\left(\frac{a(1-3r^2)}{2r}\right) - \left(\frac{b(1+r^2)}{2r}\right) < \left(\frac{a}{2r}\right) - \left(\frac{b}{2r}\right)$$

We can establish the condition for a strictly dominant *doping* strategy, (D,D) from (5.1.2) as condition 1.

Condition 1: If $c < \left(\frac{a(1-3r^2)}{2r}\right) - \left(\frac{b(1+r^2)}{2r}\right)$ then the strictly dominant strategy for both players is to choose *dope* and assuming rational players, the Nash equilibrium is at {D, D}.

By equation, (5.1.6), if Condition 1 is satisfied then the game is a Prisoners Dilemma. We can establish the condition for a strictly dominant *not-doping* strategy, (ND,ND) from (5.1.3) as condition 2.

Condition 2: If $c > \left(\frac{a}{2r}\right) - \left(\frac{b}{2r}\right)$ then the strictly dominant strategy for both players is to choose *not-dope* and assuming rational players, the Nash equilibrium is at {ND, ND}.

To find the strictly dominant strategy for player *i* we need to find the strategy s_i with the maximum payoff for any strategy that player *i*'s rivals might play. In order to do this we can first produce values of a and b then plot (5.1.4) and (5.1.5) on the (r,c) plane to determine the strictly dominant strategies on the (r,c) plane. Looking to the 2009 US Open[6] for values of *a* and *b*. The 2009 US Open[7] had a first place prize of $1.6 million, a second place prize of $800,000, the semifinalists received $350,000 while the quarter

[6] The US Open Data were gleaned from the *Official Website of the 2011 US Open*: http://www.usopen.org/News/2009/07/2009_US_Open_Base_Prize_Money_Increases/

finalists received \$175,000. For the tournament game we then have 1st place prize = \$1.6 million, 2nd place=\$800,000, 3rd place[8]=\$350,000 and 4th place=\$175,000. The prizes and associated cost of doping can be represented as parameters of the 1st place prize, Let: $aA=A$, $bA=B$, $dA=D$, $fA=F$ and $cA=C$ where, $0<f<d<b<1$ and $c>0$. In the specific case of the US Open we then have:

1st place = aA = A = \$1.6 million and $a = 1$

2nd place = bA=B = \$800,000, and $b = \dfrac{\$800{,}000}{\$1{,}600{,}000} = 0.5$

3rd place= dA = D= \$350,000 and, $d = \dfrac{\$350{,}000}{\$1{,}600{,}000} = 0.219$

4th place = fA = F=\$175,000 and, $f = \dfrac{\$175{,}000}{\$1{,}600{,}000} = 0.109$

The cost of doping = $cA = C$

Substituting into equations (5.1.4) and (5.1.5) the US Open parameters, where $a = 1$ and $b=.5$, gives Figure (5.2).

Looking at Figure 5.2, (r,c) points to the left of the red line (equation 5.1.4) will, by *Condition 1*, produce a {D,D} Nash equilibrium. While (r,c) points to the right of the

[7] This reward scheme is fairly common in professional tennis tournaments, for example Wimbledon (2009) has £850,000 for the winner, £425,000 for the runner up, £212,000 for the semi-finalists, £106,250 for the quarter-finalists.

[8] Third and fourth place would normally each receive \$350,000, but for the purposes of generalization the semifinalist prize is the 3rd place prize and the quarterfinalist prize is the 4th place prize.

blue line (equation 5.1.5) will, by *Condition 2*, produce a produce a {ND,ND} Nash equilibrium. The grey area in Figure 5.2 is unstable and will be discussed below. We can see three (r,c) combinations from Figure 5.2 which lay in the three regions, fixing r = 0.16, and assuming specific increases in c, we get (r,c) points in each region, (r,c) = (0.16, 1) is in the {D,D} region to the left of equation (5.1.4), (r,c) = (0.16, 1.5) is in the grey area between (5.1.4) and (5.1.5) and (r,c) = (0.16, 2) is in the {ND,ND} region to the right of equation (5.1.5). Substituting these (r,c) combinations into the Finals' game matrix (Figure 5.1) gives three possible strategies for the players. Looking first in the {D,D} region, (to the left of the red line in Figure 5.2), which would correspond to the payoff matrix in Figure 5.3 with (r,c) = (0.16, 1). For any choice of player 2, player 1's strategy is to choose D, if player 2 chose D then D would be the dominant strategy for player 1 since 0.71 > 0.66 and if player 2 chose ND then D would be the dominant strategy for player 1 since 0.84 > 0.75. The strictly dominant strategy for player 1 is D and by symmetry the strictly dominant strategy for player 2 is D. The Nash equilibrium for parameters (a,b,r,c) = (1,0.5,0.16,1) is {D,D}. With these parameters the game is a Prisoners Dilemma, since both players would be better off if they cooperated and both chose ND, getting a payout of 0.75 as opposed to the lower payoff of 0.71.

Jumping to the {ND,ND} region, (a,b,r,c) = (1,0.5,0.16,2), Figure 5.4, we get a Nash equilibrium at {ND,ND} since no matter what choice player 2 makes, player 1 will choose ND. With these parameters, the Nash equilibrium at {ND,ND} is also the Pareto optimal equilibrium with 0.75 being the largest expected payout possible for the players.

If (r,c) is in the grey area, (r,c) = (0.16, 1.5), Figure 5.5 then there is no dominant strategy, since if player 2 chose D, the utility maximizing strategy for player 1 is ND

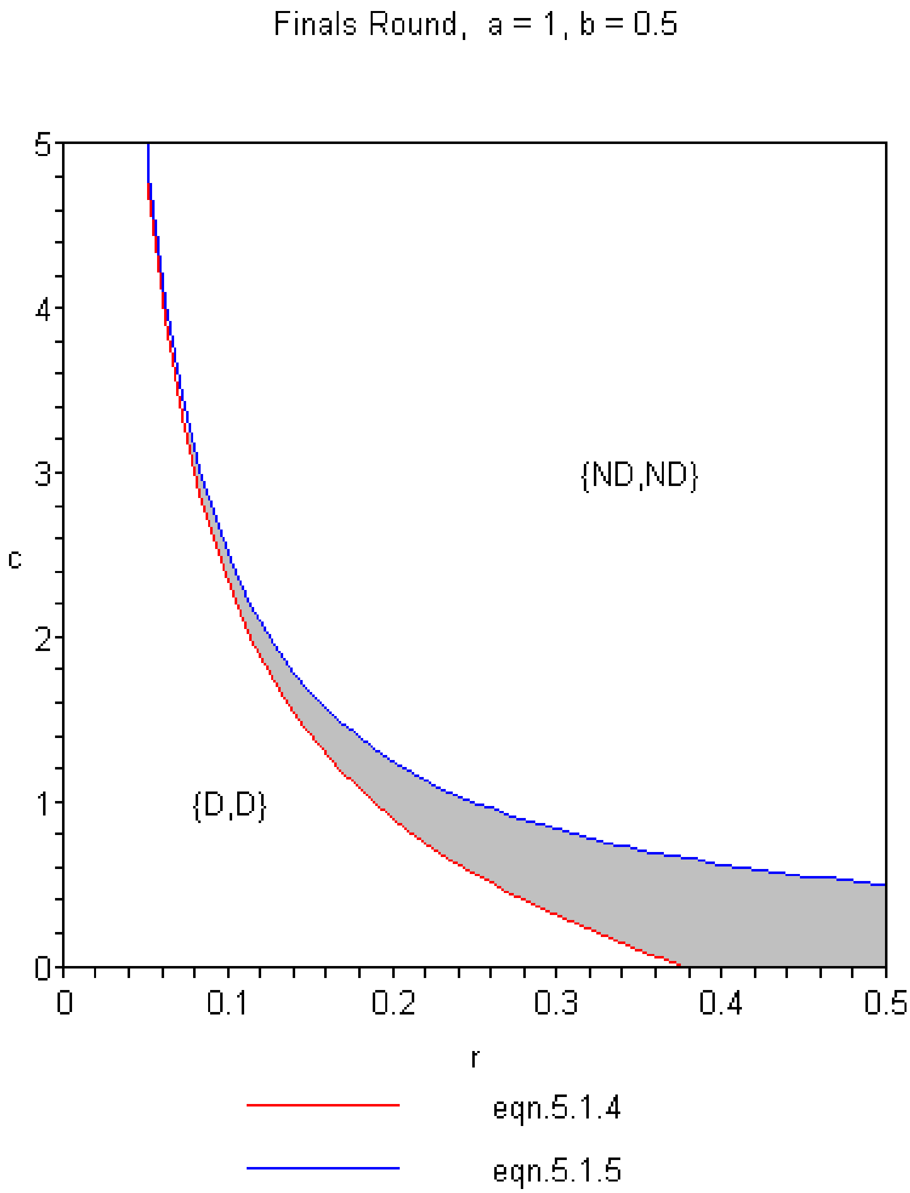

Figure 5.2: Equations 5.1.4 and 5.1.5.

		Player 2	
		D	ND
Player 1	D	(0.71, 0.71)	(0.66, 0.84)
	ND	(0.84, 0.66)	(0.75, 0.75)

Figure 5.3: Finals' game payout matrix with (r,c) = (0.16, 1),
Notes: Using the payoff convention (column, row).

		Player 2	
		D	ND
Player 1	D	(0.55, 0.55)	(0.66, 0.68)
	ND	(0.68, 0.66)	(0.75, 0.75)

Figure 5.4: Finals' game payout matrix with (r,c) = (0.16, 2).
Notes: Using the payoff convention (column, row).

since 0.66 > 0.55 and if player 2 chose ND, the utility maximizing strategy for player 1 is D since 0.76 > 0.75. Points in the grey area comprise a situation in which there is no pure strategy equilibrium, but since some strategy must be chosen (i.e., a player has to either choose to use PEDs or not) each player has to play *dope* or *not-dope* with some probability not equal to 0.

Points in the grey area of Figure 5.2 lay to the right of (5.1.4) and to the left of (5.1.5) and as such produce unstable results in the off diagonals of the Finals' Game matrix of Figure 5.1.

(5.1.7) $$\left(\frac{a\left(1-3r^{2}\right)}{2r}\right)-\left(\frac{b\left(1+r^{2}\right)}{2r}\right)<c<\left(\frac{a}{2r}\right)-\left(\frac{b}{2r}\right)$$

Therefore,

(5.1.8) $$\left[(b+rc)A > A\left(\frac{(a+b)\left(1-r^{2}\right)}{2}+ar(1-r)-cr\right)\right]$$

And

(5.1.9) $$\left[\left(\frac{(a+b)A}{2}\right)<(a-rc)A\right]$$

		Player 2	
		D	ND
Player 1	D	(0.63, 0.63)	(0.66, 0.76)
	ND	(0.76, 0.66)	(0.75, 0.75)

Figure 5.5: Finals' game payout matrix with (r,c) = (0.16, 1.5).
Notes: Using the payoff convention (column, row).

Player 1 will choose ND if player 2 chooses D and player 1 will choose D if player 1 chooses ND. In the absence of a pure strategy equilibrium for (r,c) in the grey area of Figure 5.2 we can find a mixed strategy equilibrium[9] if we allow players to randomize their strategies. The realism of mixed strategy equilibriums has been called into question. Rapoport and Boebel (1992), Mookherjee and Sopher (1994) and Ochs (1995) find little empirical evidence that players actually do play mixed strategies. One could certainly suppose that a person's choice of whether or not to use PEDs would not be done randomly, so the validity of the actual probabilities of choosing *dope* or *not-dope*, established by the assumption of players randomizing their decisions in the performance enhancing drug game could be called into question. We can use the pure strategy regions to gain some information about a players choices if (r,c) occurs in the grey region by noting that in the absence of a *not-doping* dominant pure strategy, a player will choose *(D)* with *0 < probability < 1* and in the absence of a dominant doping pure strategy, a player will choose *(ND)* with *0 < probability < 1*. The relevance of this point will come into play when discussing an organizing body's policy choices to deter doping. It would certainly be a better outcome for an organizing body wishing to deter doping that athlete's would choose *not-dope* with certainty over *dope* with *probability > 0*. We can then establish *Condition 3*.

***Condition 3*:** If $\left(\dfrac{a(1-3r^2)}{2r}\right)-\left(\dfrac{b(1+r^2)}{2r}\right)<c<\left(\dfrac{a}{2r}\right)-\left(\dfrac{b}{2r}\right)$ then all players will choose D with *0 < probability < 1* and ND with *0 < probability < 1.*

[9] If players are assumed to randomize their strategies then the mixed strategy Nash equilibrium for (r,c)=(0.16,1.5) is at (D, ND) = (0.22, 0.78).

5.4 Losers' Game

The payout matrix and Nash equilibrium conditions for the Losers' Round can be determined by substituting *dA* for *aA* from the Finals' Round and *fA* for *bA* from the Finals' Round. The 2x2 matrix, Figure 5.6 shows the expected payouts for the Losers' Round the Losers' game.

Similar to the Finals' game, the dominant strategies in the Qualifying Round depends on the relationships expressed in (5.2.0) and (5.2.1).

(5.2.0) $$(f + rc)A : A\left(\frac{(d + f)(1 - r^2)}{2} + dr(1 - r) - cr\right)$$

(5.2.1) $$\left(\frac{(d + f)A}{2}\right) : (d - rc)A$$

As above we can set both sides of equations (5.2.0) and (5.2.1) equal and solve for c to get (5.2.2) and (5.2.3) which are plotted on (r,c) in Figure 5.7 using the US Open reward scheme where $d = 0.219$ and $f = 0.109$.

(5.2.2) $$c = \left(\frac{d(1 - 3r^2)}{2r}\right) - \left(\frac{f(1 + r^2)}{2r}\right)$$

(5.2.3) $$c = \left(\frac{d}{2r}\right) - \left(\frac{f}{2r}\right)$$

		Player 2	
		D	ND
Player 1	D	$\left[\begin{array}{l} A\left(\frac{(d+f)(1-r^2)}{2}+dr(1-r)-cr\right), \\ A\left(\frac{(d+f)(1-r^2)}{2}+dr(1-r)-cr\right) \end{array}\right],$	$(f+rd)A,(d-rc)A,$
	ND	$(d-rc)A,(f+rd)A$	$\left(\frac{(d+f)A}{2}\right),\left(\frac{(d+f)A}{2}\right)$

Figure 5.6: Losers' game matrix.
Notes: Using the payoff convention (column, row).

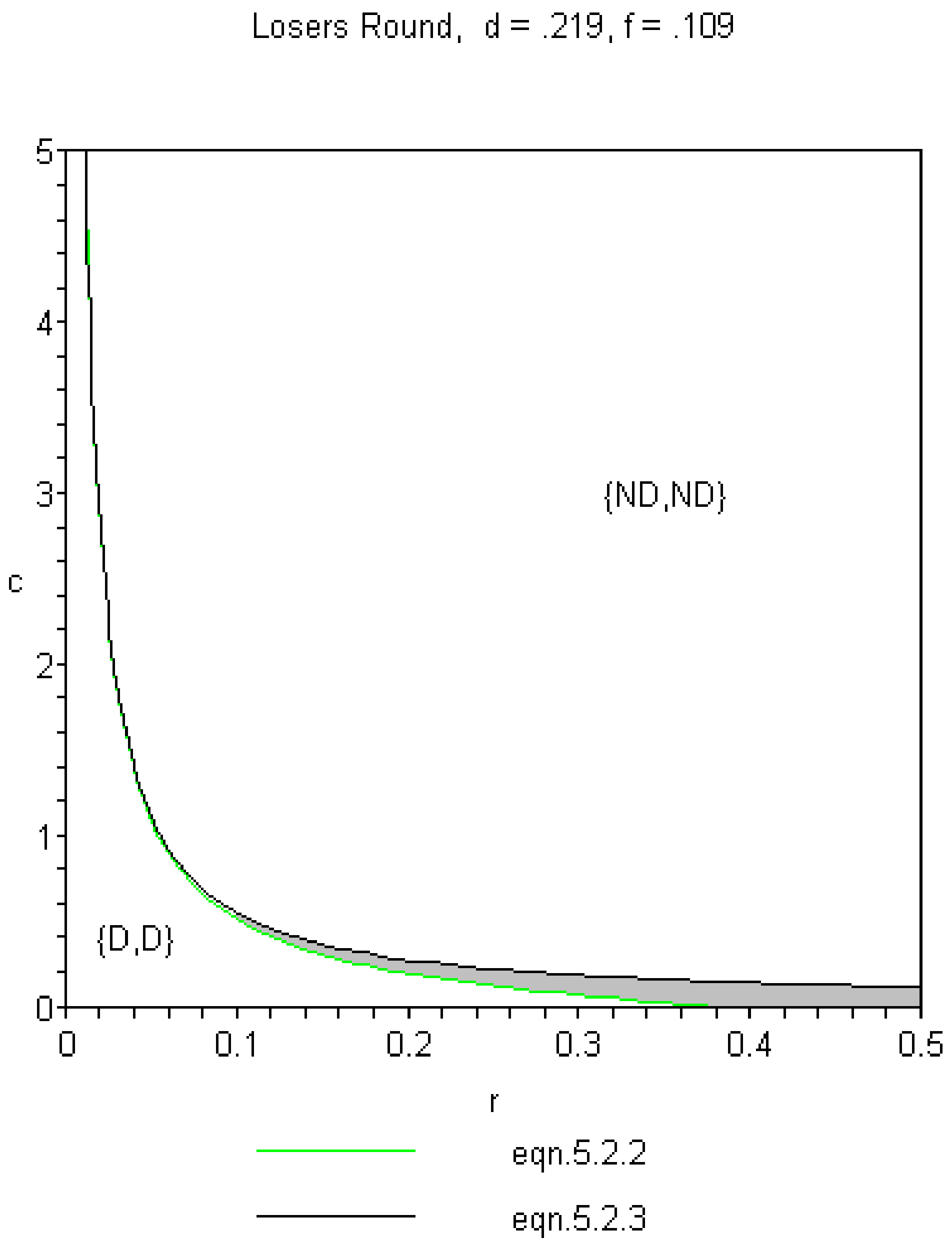

Figure 5.7: Equations 5.2.2 and 5.2.3.

Using the analysis above for the Finals' Round allows us to establish Condition 4 and Condition 5 for the Losers' Round.

Condition 4: If $c < \left(\frac{d\left(1-3r^2\right)}{2r}\right) - \left(\frac{f\left(1+r^2\right)}{2r}\right)$ then the strictly for both players is choose *dope* and assuming rational players, the Nash equilibrium is at $\{D,D\}$.

Furthermore, as above this will be a prisoner's dilemma game.

Condition 5: If $c > \left(\frac{d}{2r}\right) - \left(\frac{f}{2r}\right)$ then the strictly for both players is choose *not-dope* and assuming rational players, the Nash equilibrium is at $\{ND,ND\}$.

As above, the grey area produces off diagonal unstable results and by the above argument establishes *Condition 6*.

***Condition 6*:** If $\left(\frac{d\left(1-3r^2\right)}{2r}\right) - \left(\frac{f\left(1+r^2\right)}{2r}\right) < c < \left(\frac{d}{2r}\right) - \left(\frac{f}{2r}\right)$ then all players will choose D with *0 < probability < 1* and ND with *0 < probability < 1.*

5.5 Qualifiers

The Qualifying Round would consist of two games in which four different players competed one-on-one against each other. Assuming all players are perfectly rational and equally skilled, the Qualifying Round can be modeled as one game but payoffs need to be recalculated to reflect the greater number of potential outcomes in the rounds which follow. Let л be the prize for winning the Qualifying Round, namely the expected payoff from the Finals' Round. Let µ be the prize for losing in the Qualifying Round, namely the expected payoffs from the Losers' Round. Later the values of *aA*, *bA*, *dA* and *fA* can be substituted back in.

{ND, ND}: Each player has an equal probability of winning the Qualifying Round with an expected payout of л. Each player also has an equal probability of moving on to the Losers' Round with an expected payout of µ. There is also the chance that one player from the other Qualifying Round will be disqualified while the other is not which will guarantee a 3rd place prize to the losers of the Qualifying Round of D with $(1-r)r$ probability and expected payout of $(1-r)rD$. If both players from the other Qualifying Round are disqualified which happens with probability r^2 then the loser of the Qualifying Round moves to the Finals' Round with expected payout, л. The expected payoffs in the Qualifying Round if both players choose ND are then (P4).

$$\text{(P4)} \qquad \{\text{ND, ND}\}: \left\{ \left(\frac{\pi+\mu}{2} + (1-r)rD + \pi r^2 \right), \left(\frac{\pi+\mu}{2} + (1-r)rD + \pi r^2 \right) \right\}$$

{D, ND}: If player 1 chooses *dope* while player 2 chooses *not-dope* then player 1 will win with certainty and move on to the Finals' Round with expected payout, л but, due to doping, also has the chance, r of being caught in the first round[10] and fined C, resulting in an expected payout: л – rC. If player 1 chooses *dope* while player 2 chooses *not-dope* then player 2 has no probability of being caught doping in the first round and will move onto the Losers' Round with an expected payout of μ if player 1 is not caught doping. If player 1 is caught doping then player 2 will move on to compete in the Finals' Round, so player 2 has a probability r of obtaining the winning payoff л. There is again the chance that one player from the other Qualifying Round will be disqualified while the other is not which will guarantee a 3rd place prize of D with $(1-r)r$ probability and expected payout of $(1-r)rD$ or both players from the other Qualifying Round are disqualified, which happens with probability r^2, and a chance to win the final prize of л. If it is assumed that the match outcome and test outcome are independent then player 2's expected payoff if athlete 1 chooses *dope* is then, $\mu + (1-r)rD + \pi r^2 + \pi r$. The expected payoffs for the two players if one chooses D and the other chooses ND are (P5).

(P5) $$\{D, ND\}: \{л - rC,\ \mu + (1-r)rD + \pi r^2 + \pi r\ \}$$

{D,D}: If both players choose *dope* then they each have a 0.5 probability of winning and moving on to the Finals' with expected payout, л. But, since the drug

[10] The athlete has the chance of being caught in the first round or the second round, but the chance of being caught and fined in the second round is taken into account in л.

affects each equally they each have a 0.5 probability of losing in the Qualifier Round and moving onto the Losers' Round for an expected payout of μ. This is the case only if neither is caught which happens with a probability of $(1-r)^2$ resulting in an expected payout: $\frac{\pi(1-r)^2}{2}+\frac{\mu(1-r)^2}{2}$. It could also be the case that one player is caught while the other is not which happens with a $(1-r)r$ probability and expected payout to the player that is not caught of, л$(1-r)r$. On the other hand, it could also be the case that one doped player is caught while the other is not resulting in an expected monetary loss to the player caught of, - $C(1-r)r$. Both athletes are caught with probability r^2 and expected monetary loss: -Cr^2. Of course, the other Qualifying Round needs to be taken into account as well.

If one or the other player is caught and disqualified in the other Qualifying Round, which happens with $(1-r)r$ probability then the player who loses in the qualifiers will be guaranteed the 3rd place prize of D, while if both the other players are caught and disqualified she will move onto the Finals' Round with probability r^2 and payout of л. The expected payouts if both athletes choose D are then (P5).

$$\{ \frac{\pi(1-r)^2}{2}+\frac{\mu(1-r)^2}{2}+\pi(1-r)r-C(1-r)r-Cr^2+(1-r)rD+\pi r^2 \ ,$$

$$\text{(P5)} \ \{\text{D, D}\}: \ \frac{\pi(1-r)^2}{2}+\frac{\mu(1-r)^2}{2}+\pi(1-r)r-C(1-r)r-Cr^2+(1-r)rD+\pi r^2 \ \} \rightarrow$$

$$\{ \frac{\pi}{2}\left(1+r^2\right)+\frac{\mu}{2}\left(1-2r+r^2\right)+(1-r)rD-Cr \ ,$$

$$\frac{\pi}{2}\left(1+r^2\right)+\frac{\mu}{2}\left(1-2r+r^2\right)+(1-r)rD-Cr \ \}$$

We can then use these payouts to establish the 2x2 game matrix for the Qualifying Round, Figure 5.8. Like the Finals' and Losers' Round, dominant strategies are determined by the relationships in (5.3.1) and (5.3.2).

(5.3.1) $$\mu + (1-r)rD + \pi r^2 + \pi r : \frac{\pi}{2}(1+r^2) + \frac{\mu}{2}(1-2r+r^2) + (1-r)rD - Cr$$

(5.3.2) $$\left(\frac{\pi+\mu}{2} + (1-r)rD + \pi r^2\right) : \pi - rC$$

Setting the two sides of (5.3.1) and (5.3.2) equal and solving for C, (5.3.1) becomes (5.3.3) and (5.3.2) becomes (5.3.4).

(5.3.3) $$C = \frac{\mu(r^2-2r-1) + \pi(1-r^2-2r)}{2r}$$

(5.3.4) $$C = \frac{\pi(1-2r^2) - \mu - 2rD(1-r)}{2r}$$

The values of (5.3.3) and (5.3.4) determine the player strategies in the Qualifying Round but the values of the right hand side of (5.3.3) and (5.3.4) are determined by the player's strategies in the Finals' Round and the Losers' Round. We need to determine the values of (r,c) and the associated player doping strategies for the following rounds which, given varying expected costs of doping, can be determined from the already established conditions.

		Player 2	
		D	ND
Player 1	D	$\frac{\pi}{2}\left(1+r^2\right)+\frac{\mu}{2}\left(1-2r+r^2\right)+\left(1-r\right)rD-Cr$, $\frac{\pi}{2}\left(1+r^2\right)+\frac{\mu}{2}\left(1-2r+r^2\right)+\left(1-r\right)rD-Cr$	$\mu+\left(1-r\right)rD+\pi r^2+\pi r$, л - rC
	ND	л - rC, $\mu+\left(1-r\right)rD+\pi r^2+\pi r$	$\left(\frac{\pi+\mu}{2}+(1-r)rD+\pi r^2\right)$, $\left(\frac{\pi+\mu}{2}+(1-r)rD+\pi r^2\right)$

Figure 5.8: Game matrix for the Qualifying Round.
Notes: Using the payoff convention (column, row).

5.6 Expected Cost Regions

Assuming only pure strategy equilibriums within each game there are three potential player strategies for three (r,c) regions.

Region (i): The expected cost of doping, *rc* is large enough such that both players choose *not-dope* and thus guarantees a strictly dominant pure strategy of ND for both players.

Region (ii): The expected cost of doping, *rc* is small enough such that both players choose *dope* and thus guarantees a strictly dominant pure strategy of D for both players.

Region (iii): The expected cost of doping, rc is large enough such that both players choose ND in the Losers' Round but the expected cost of doping is small enough such that both players choose dope in the Finals'. In Region (iii) there is a strictly dominant strategy of ND in the Losers' Round and a strictly dominant strategy of D in the Finals' Round.

Furthermore, since in the vast majority of sporting tournaments, relative prizes are not larger in the Losers' Round than they are in the Finals' Round,[11] *Assumption j* is made.

Assumption (j): $a - b \geq d - f$

[11] The author is not aware of any situations where this is not the case, but if there is one then this analysis cannot be applied.

5.6.1 Region (i). If *Condition (2)* is satisfied (i.e., $c > \left(\frac{a}{2r}\right) - \left(\frac{b}{2r}\right)$) then with *Assumption (j)*, *Condition 4* is satisfied (i.e., $c > \left(\frac{d}{2r}\right) - \left(\frac{f}{2r}\right)$) and there is an {ND, ND} Nash equilibrium in the Finals' and the Losers' Round.[12] The expected payouts in the Qualifying Round for *Region (i)* would then be (5.3.5) and (5.3.6).

(5.3.5) Qualifying Round Win = $\pi = \alpha = \left(\frac{(a+b)A}{2}\right)$ if *Condition 2* and *Condition 5* are satisfied.

(5.3.6) Qualifying Round Loss = $\mu = \delta = \left(\frac{(d+f)A}{2}\right)$ if *Condition 2* and *Condition 5* are satisfied.

Substituting the payouts in (5.3.5) and (5.3.6) into (5.3.3) and dividing through by *A*, gives (5.3.7).

(5.3.7)
$$c = \frac{a(1-r^2-2r)}{4r} + \frac{b(1-r^2-2r)}{4r} + \frac{d(r^2-2r-1)}{4r} + \frac{f(r^2-2r-1)}{4r}$$

Substituting (5.3.5) and (5.3.6) into (5.3.4) gives (5.3.8).

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[12] Assumption j allows us to say that: $\left(\frac{a}{2r}\right) - \left(\frac{b}{2r}\right) > \left(\frac{d}{2r}\right) - \left(\frac{f}{2r}\right)$.

(5.3.8) $$c = \frac{a(1-2r^2)}{4r} + \frac{b(1-2r^2)}{4r} + \frac{d(4r^2-4r-1)}{4r} - \frac{f}{4r}$$

To determine the strategy spaces each strategy will be numerically solved for the US Open parameters *a=1*, *b= 0.5, d*=0.219 and *f* = 0.109. From these parameters the strategy spaces, in terms of the probability of being caught doping, *r* and the fine for being caught, $cA = C$, can be determined. Equations (5.3.7) and (5.3.8) along with the reaction curves from the Finals' Round, ((5.1.4), (5.1.5)) and Losers' Round, ((5.2.2), (5.2.3)) are plotted on (r,c) for the US Open parameter values in Figure 5.9.

If the expected cost of doping, (rc) is large enough to deter doping in the Finals' Round (the dark grey region) then it will certainly be large enough to deter doping in the Losers' Round, since all (r,c) to the right of (5.1.5) are to the right of (5.2.3). Equations (5.1.5) and (5.3.8) cross at (r,c) = (0.145, 1.72) subsequently an expected cost of doping sufficiently large enough to satisfy *Condition 2* will establish a dominant *not-doping* pure strategy in the tournament if $1.72 > c > \left(\frac{a}{2r}\right) - \left(\frac{b}{2r}\right)$ but for c > 1.72 we need to look to (5.3.8) where, $c > \frac{a(1-2r^2)}{4r} + \frac{b(1-2r^2)}{4r} + \frac{d(4r^2-4r-1)}{4r} - \frac{f}{4r} > 1.72$ to establish the strictly dominant *not-doping* strategy, *Condition 7,* which is the union of the two sets.

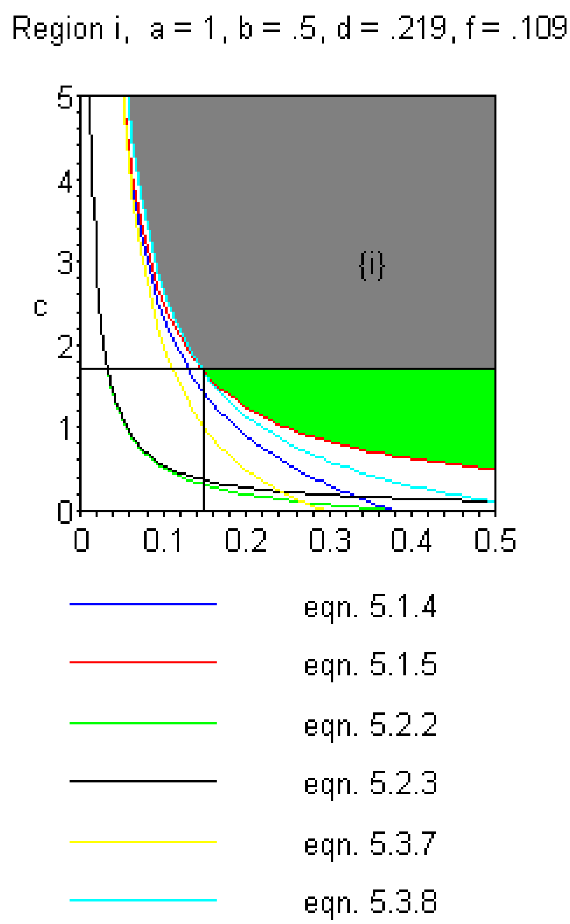

Figure 5.9: *Region i*. Equations: 5.1.4, 5.1.5, 5.2.2, 5.2.3, 5.3.11 and 5.3.12.

Condition 7: If,

$$c > \left(\frac{a}{2r}\right) - \left(\frac{b}{2r}\right) \;\&\; c > \frac{a\left(1-2r^2\right)}{4r} + \frac{b\left(1-2r^2\right)}{4r} + \frac{d\left(4r^2-4r-1\right)}{4r} - \frac{f}{4r}$$

then the strictly dominant strategy for all players is to choose *not-dope* and assuming rational players, the pure strategy Nash equilibrium for the Qualifying Round is at {ND, ND}.

We can see how this plays out with a numerical example. The payout equations for *Region i* are represented in the 2x2 matrix (Figure 5.10). Payouts are symmetric. For simplicity only player 1's payouts are shown.

An expected cost which would satisfy *Condition 7* would be (r,c) = (0.3, 1), the expected payouts are calculated in Figure 5.11, normalizing the payouts and dividing through by A. If (r,c) = (0.3, 1) then the dominant strategy for player 1 is ND and with symmetric payouts, the dominant strategy for player 2 is ND and there is a pure strategy Nash Equilibrium at {ND, ND}.

5.6.2 *Region (ii).* If *Condition 4* is satisfied, (i.e., $c < \left(\frac{d\left(1-3r^2\right)}{2r}\right) - \left(\frac{f\left(1+r^2\right)}{2r}\right)$) then with *assumption (j), Condition 1* is satisfied (i.e., $c < \left(\frac{a\left(1-3r^2\right)}{2r}\right) - \left(\frac{b\left(1+r^2\right)}{2r}\right)$) and there is a {D,D} Nash equilibrium in the Finals' Round and the Losers' Round.[13] The

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[13] Assumption j allows us to say that:
$\left(\frac{d\left(1-3r^2\right)}{2r}\right) - \left(\frac{f\left(1+r^2\right)}{2r}\right) < \left(\frac{a\left(1-3r^2\right)}{2r}\right) - \left(\frac{b\left(1+r^2\right)}{2r}\right)$.

		Player 2 plays D	Player 2 plays ND
Player 1	D	$\left[\begin{array}{l}\dfrac{(a+b)(1+r^2)+(d+f)(1-2r+r^2)}{4}\\ +rd(1-r)-rc\end{array}\right]A$	$\left[\dfrac{(a+b)}{2}-rc\right]A$
	ND	$\left[\dfrac{(d+f)+(a+b)r^2+(a+b)r}{2}+dr(1-r)\right]A$	$\left[\begin{array}{l}\dfrac{(a+b+d+f)}{4}\\ +\dfrac{(a+b)r^2}{2}+dr(1-r)\end{array}\right]A$

Figure 5.10: Game matrix of expected payouts for Player *i* in the tournament.

		Player 2 plays D	Player 2 plays ND
Player 1	D	0.195	0.450
	ND	0.502	0.570

Figure 5.11: Game matrix of expected payouts for Player *i* in the tournament, (r,c) = (0.3,1), a= 1, b=.5,d=.219, f=.109.

expected payouts in the Qualifying Round for *Region (ii)* would then be (5.3.9) and (5.3.10).

(5.3.9) Qualifying Round Win = $\pi = \varphi = A\left(\frac{(a+b)(1-r^2)}{2} + ar(1-r) - cr\right)$ if *Condition 4* and *Condition 1* are satisfied.

(5.3.10) Qualifying Round Loss = $\mu = \gamma = A\left(\frac{(d+f)(1-r^2)}{2} + dr(1-r) - cr\right)$ if *Condition 4* and *Condition 1* are satisfied.

Substituting the payouts in (5.3.9) and (5.3.10) into (5.3.3) gives (5.3.11).

(5.3.11)
$$c = \frac{\begin{pmatrix} a\left(8r^2 - 4r^3 - 3r^4 - 1\right) + b\left(2r + 2r^2 - 2r^3 - r^4 - 1\right) \\ + d\left(4r - 8r^3 + 3r^4 + 1\right) + f\left(1 + 2r - 2r^2 - 2r^3 + r^4\right) \end{pmatrix}}{8r^2 - 4r}$$

Substituting (5.3.9) and (5.3.10) into (5.3.4) gives (5.3.12).

(5.3.12)
$$c = \frac{a\left(1 + 3r - 2r^2 - 6r^3\right) + b\left(1 + r - 2r^2 - 2r^3\right) + d\left(-7r - 1\right) + f\left(-1 - r\right)}{4r^2 + r}$$

Equations (5.3.10) and (5.3.12) along with the reaction curves from the Finals' Round, ((5.1.4), (5.1.5)) and Losers' Round, ((5.2.2), (5.2.3)) are plotted on (r,c) for the US Open parameter values in Figure 5.12.

If the expected cost of doping is small enough to create an incentive for doping in the Losers' Round then it will certainly be small enough to create an incentive for doping in the Finals' Round (the light grey area of Figure 5.12), since all (r,c) to the left of (5.2.2) are to the left of (5.1.4). Equations (5.2.2) and (5.3.10) cross at (r,c) = (0.276, 0.096)

subsequently a cost of doping sufficiently small enough to create a dominant pure strategy of doping in the Losers' Round will establish a dominant doping strategy in the Qualifying Round if $0.096 < c < \left(\frac{d\left(1-3r^2\right)}{2r}\right)-\left(\frac{f\left(1+r^2\right)}{2r}\right)$ and

$$c = \frac{\begin{pmatrix} a\left(8r^2-4r^3-3r^4-1\right)+b\left(2r+2r^2-2r^3-r^4-1\right) \\ +d\left(4r-8r^3+3r^4+1\right)+f\left(1+2r-2r^2-2r^3+r^4\right) \end{pmatrix}}{8r^2-4r}.$$

This allows for establishing Condition 8, the strictly dominant D strategy in the tournament.

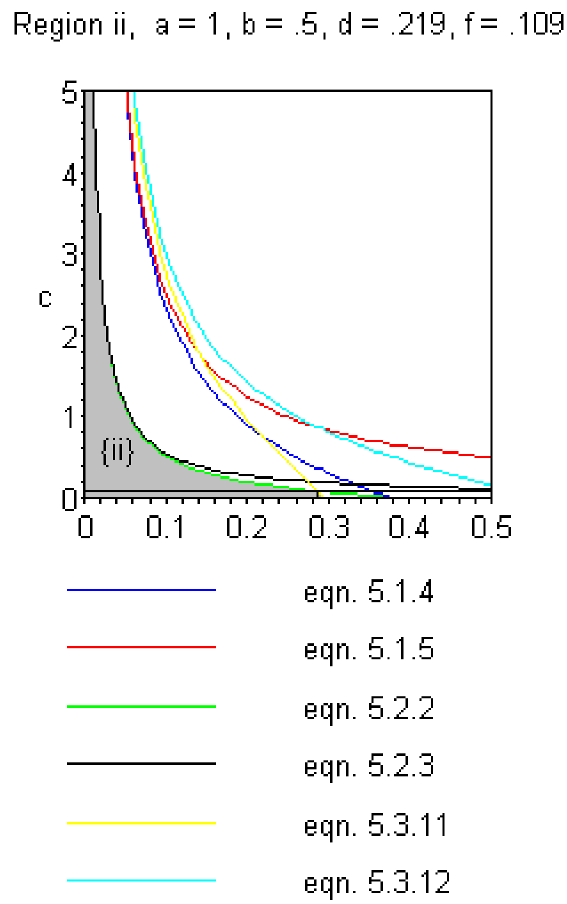

Figure 5.12: *Region ii*. Equations: 5.1.4, 5.1.5, 5.2.2, 5.2.3, 5.3.11 and 5.3.12.

Condition 8: If,

$$c < \left(\frac{d\left(1-3r^2\right)}{2r}\right) - \left(\frac{f\left(1+r^2\right)}{2r}\right) \ \&$$

$$c = \frac{\begin{pmatrix} a\left(8r^2 - 4r^3 - 3r^4 - 1\right) + b\left(2r + 2r^2 - 2r^3 - r^4 - 1\right) \\ + d\left(4r - 8r^3 + 3r^4 + 1\right) + f\left(1 + 2r - 2r^2 - 2r^3 + r^4\right) \end{pmatrix}}{8r^2 - 4r}$$

then the strictly dominant strategy for all players is choose *dope* and assuming rational players, the pure strategy Nash equilibrium for the Qualifying Round is at {D,D}.

Furthermore, if *Condition 8* is satisfied then the tournament game will be a Prisoners Dilemma.

We can again use a numerical example as a demonstration. Using the US Open parameters, normalizing by dividing through by A and letting (r,c) = (0.04, 1) then substituting the expected payouts from (5.3.9) and (5.3.10) into the matrix of Figure 5.8 gives Figure 5.13. If (r,c) = (0.04,1) then the dominant strategy for player 1 is D and with symmetric payouts, the dominant strategy for player 2 is D and there is a pure strategy Nash equilibrium at {D,D}.

5.6.3 Region iii. If *Condition 5* is satisfied (i.e. $c > \left(\frac{d}{2r}\right) - \left(\frac{f}{2r}\right)$), but *Condition 2* is not satisfied (i.e., $c < \left(\frac{a}{2r}\right) - \left(\frac{b}{2r}\right)$) then there will be a pure strategy Nash equilibrium at {ND, ND} in the Losers' Round and assuming only pure strategies a pure

		Player 2 plays D	Player 2 plays ND
Player 1	D	0.404	0.707
	ND	0.172	0.449

Figure 5.13: Game matrix of expected payouts for Player *i* in the tournament, (r,c) = (0.04,1), a= 1, b=.5,d=.219, f=.109.

strategy {D, D} in the Finals' Round. The expected payouts in the Qualifying Round for *Region iii* are then (5.3.13) and (5.3.14).

(5.3.13) Qualifying Round Win = $\pi = \Psi = A\left(\frac{(a+b)(1-r^2)}{2} + ar(1-r) - cr\right)$ if

Condition 2 is not satisfied and *Condition 5* is satisfied.

(5.3.14) Qualifying Round Loss = $\mu = \Omega = \left(\frac{(d+f)A}{2}\right)$ if *Condition 2* is not satisfied and

Condition 5 is satisfied.

Substituting the payouts in (5.3.13) and (5.3.14) into (5.3.3).

(5.3.15) $$c = \frac{a(2r + 2r^2 - 2r^3 - r^4 - 1) + b(8r^2 - 4r^3 - 3r^4 - 1) + d(2r - r^2 + 1) + (2r - r^2)}{2r(2r + r^2 - 3)}$$

Substituting (5.3.13) and (5.3.14) into (5.3.4).

(5.3.16) $$c = \frac{a(3r^2 - 2r^4 - 1) + b(5r^2 + 4r^3 - 6r^4 - 2r - 1) + d(4r - 4r^2 + 1) - f}{2r(2r^2 - 3)}$$

Equations (5.3.15) and (5.3.16) along with the reaction curves from the Finals' Round, ((5.1.4), (5.1.5)) and Losers' Round, ((5.2.2), (5.2.3)) are plotted on (r,c) for the US Open parameter values in Figure 5.14.

The light blue area of Figure 5.14 is the region where the expected cost of doping is large enough for a dominant *not-doping* strategy in the Losers' Round (i.e., *Condition 5* is satisfied) but is not large enough for a dominant *not-doping* strategy in the Finals' Round (i.e., *Condition 1* is satisfied). If this were a oneshot game with the payouts being a and b then the dominant pure strategy would be D for both players, but if it were a one shot game with payouts d and f then the dominant pure strategy would be ND for both players. In the case of the tournament, if the expected cost is large enough to deter doping in the Losers' Round but small enough to not deter doping in the Finals' Round there will be a dominant pure strategy of D in the Qualifying Round, from this we can get *Condition 9*. In this region there is a strictly dominant pure strategy of doping in the Qualifying Rounds which establishes *Condition 9*.

Condition 9: If $\left(\frac{d(1-3r^2)}{2r}\right)-\left(\frac{f(1+r^2)}{2r}\right)<c<\frac{\begin{pmatrix} a(2r+2r^2-2r^3-r^4-1) \\ +b(8r^2-4r^3-3r^4-1) \\ +d(2r-r^2+1)+(2r-r^2) \end{pmatrix}}{2r(2r+r^2-3)}$ then

the strictly dominant strategy for all players is choose *dope*, assuming rational players, the pure strategy Nash equilibrium for the tournament is at {D,D} in the Qualifying Round and {ND,ND} in the Losers' Round.

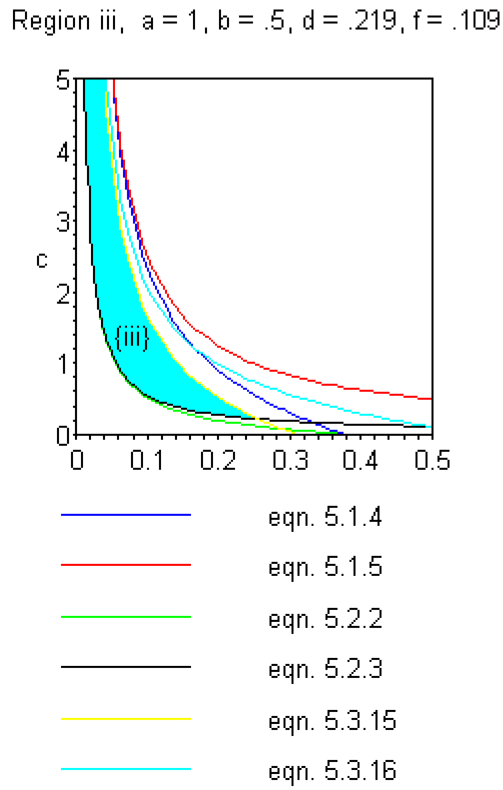

Figure 5.14: *Region iii*. Equations: 5.1.4, 5.1.5, 5.2.2, 5.2.3, 5.3.15 and 5.3.16.

A comparative numerical example might be useful here. Using the US Open parameters, normalizing by dividing through by A and letting (r,c) = (0.06, 2) then substituting the expected payouts from (5.3.13) and (5.3.14) into the matrix of Figure 5.8 gives Figure 5.15.

If (r,c) = (0.06,2) then the dominant strategy for player 1 is D and with symmetric payouts, the dominant strategy for player 2 is D and there is a pure strategy Nash equilibrium at {D,D}. On the other hand, using these same expected costs, (r,c) = (0.06,2) in the Losers' Round matrix (Figure 5.6) gives the expected payouts in Figure 5.16. From this we see that there is a pure strategy *not-doping* Nash equilibrium in the Losers' Round.

5.7 Tournament Equilibrium

The Pure strategy Nash equilibrium for the Tournament game can be determined by *Condition 7*, *Condition 8* and *Condition 9*. From *Condition 7* we get *C7*.

C7: If c > (5.5.5) & c > (5.3.8) then there is a pure strategy Nash equilibrium at {ND,ND}.

From *Condition 8* we get *C8*.

C8: If c < (5.2.2) & c < (5.3.11) then there is a pure strategy Nash Equilibrium at {D,D}.

From *Condition 9* we get *C9*.

		Player 2 plays D	Player 2 plays ND
Player 1	D	0.308	0.564
	ND	0.220	0.439

Figure 5.15: Game matrix of expected payouts for Player *i* in the tournament, (r,c) = (0.06,2), a= 1, b=.5,d=.219, f=.109.

		Player 2 plays D	Player 2 plays ND
Player 1	D	0.056	0.099
	ND	0.122	0.164

Figure 5.16: Game matrix of expected payouts for Player *i* in the Losers' Round, (r,c) = (0.06,2), a= 1, b=.5,d=.219, f=.109.

C9: If c > (5.2.2) & c < (5.3.15) then there is a pure strategy Nash Equilibrium at {D,D}.

Figure 5.17, plots (5.1.5), (5.2.2), (5.3.8), (5.3.11) and (5.3.15) on the (r,c) plane. From Figure 5.17 we see that expected costs, *rc*, which satisfy *C9* will also satisfy *C8*, thus only (5.3.15) is necessary for a {D, D} pure strategy Nash equilibrium. The dominant pure strategy Nash Equilibriums for the Tournament are then Condition-ND and Condition-D.

Condition-ND: If,

$$c > \left(\frac{a}{2r}\right) - \left(\frac{b}{2r}\right) \;\&\; c > \frac{a\left(1-2r^2\right)}{4r} + \frac{b\left(1-2r^2\right)}{4r} + \frac{d\left(4r^2-4r-1\right)}{4r} - \frac{f}{4r}$$

then the strictly dominant strategy for all players is to choose *not-dope* in all rounds of the tournament and assuming rational players, the pure strategy Nash equilibrium for the tournament is at {ND, ND}.

Condition-D: If,

$$c < \frac{a\left(2r+2r^2-2r^3-r^4-1\right)+b\left(8r^2-4r^3-3r^4-1\right)+d\left(2r-r^2+1\right)+\left(2r-r^2\right)}{2r\left(2r+r^2-3\right)}$$

then the strictly dominant strategy for all players is to choose *dope* in all rounds of the tournament and assuming rational players, the pure strategy Nash equilibrium for the tournament is at {D, D}.

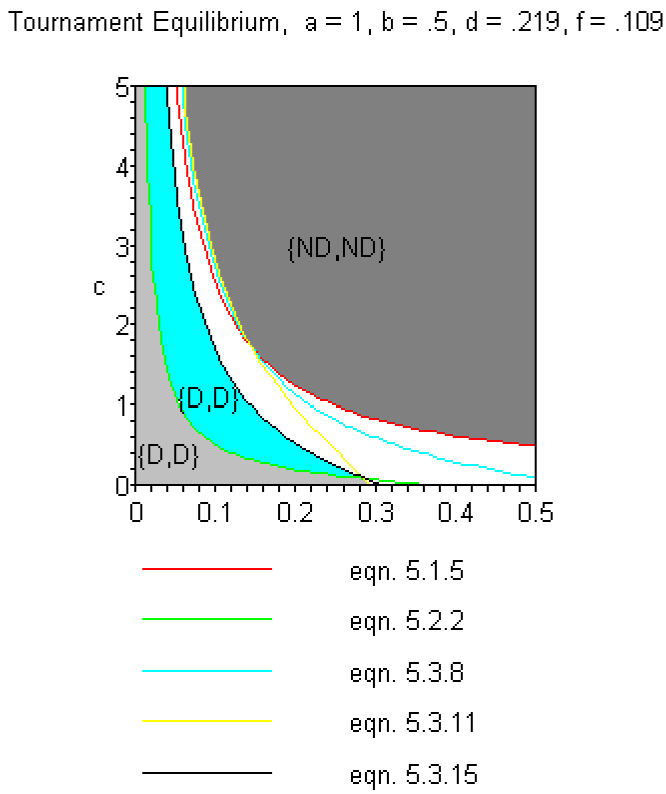

Figure 5.17: Tournament equilibrium: 5.1.5, 5.2.2, 5.3.8, 5.3.11 and 5.3.15.

An example of how sporting organizing bodies can use the Performance Enhancing Drug game could be useful here. The probability of being caught doping is indeterminate since we do not know the number of athletes using drugs. In order to make a decision the rational athlete will have to make an estimate as to what they believe the probability of them being caught in fact is. What we can do with the Performance Enhancing Drug game is compute the required costs necessary to deter doping given various estimates on the probability of being caught. It has been assumed throughout this chapter that the probability of being caught is less than 0.5. Using the equations derived in the No-Doping equilibrium (*Condition-ND*) pure strategy and the Doping equilibrium *(Condition-D)* pure strategy we can determine the penalty required to deter doping as a percentage of the first place prize, A, for four different probabilities of being caught, r = 0.1, r = 0.2, r = 0.3 and r = 0.4. Table 5.1 reports values of c for each value of r, where c is computed from the equations in *Condition-ND* and *Condition-D*.

The penalties for being caught doping vary from sport to sport, the penalty for professional tennis is a 2-year suspension from competition. We can estimate the cost of doping to any athlete by letting the expected fine be equal to two times the player's winnings over the course of 1 year. Table 5.2 lists average player prize winnings separated by groups and the cost to an athlete in this group of being caught. These do not include endorsements or salaries. The reward for winning the 2009 US Open is $1.6 million.

We can use Table 5.1 and Table 5.2 to determine athlete strategies. Table 5.1 gives the cost of doping for five different probabilities of being caught and Table 5.2 gives the cost of doping for the various ranked female tennis players. If the probability of

Table 5.1

D, D and ND, ND regions for different probabilities of being caught

Probability of being caught	ND,ND	D,D
0.1	$c > 2.658$	$c < 1.658$
0.2	$c > 1.250$	$c < 0.527$
0.3	$c > 0.833$	$c < 0.042$
0.4	$c > 0.625$	$c < 0$
0.49	$c > 0.510$	$c < 0$

Table 5.2

Rank and prize winnings for the 2009 Women's Tennis Association (WTA)

Rank	Average Winnings	$c = \frac{2xAvg.Winnings}{\$1,600,000}$	Rank	Average Winnings	$c = \frac{2xAvg.Winnings}{\$1,600,000}$
Top 10	$3,023,833	3.780	61 to 70	$316,698	0.396
11 to 20	$989,056	1.236	71 to 80	$255,802	0.320
21 to 30	$688,638	0.861	81 to 90	$206,389	0.258
31 to 40	$555,812	0.695	91 to 100	$185,404	0.232
41 to 50	$467,788	0.585	Top 50	$1,145,025	1.431
51 to 60	$372,943	0.466	Bottom 50	$267,447	0.334

Notes: Data sourced from ESPN Tennis.

being caught doping is 0.1 then the cost of a 2-year suspension will only be sufficient to deter the top 10 players from doping. The pure strategy for all athletes outside of the top 10 is to use dope, since the cost of doping for these rankings is less than 1.658. Increasing the probability of being caught to 0.2 deters the top 20 players from doping, any player outside of the top 50 will have a pure strategy of doping and players between 21 and 50 will choose dope with a positive probability. Further increasing the probability of being caught to 0.3 deters the top 30 from doping, but there is no pure strategy of doping for all the other players. If the probability of being caught is 0.4 then the pure strategy is not dope for the top 50 with the others choosing dope with $0 < probability < 1$. At a probability of being caught doping at 0.4 would require negative costs to establish a pure strategy of doping, since costs are assumed to be greater than zero there will be no pure strategy doping equilibrium for such a high probability of being caught. Even when the probability of being caught is as high as 0.49 there will still not be a pure strategy *not-doping* equilibrium for players outside of the top 50.

5.8 Discussion

This analysis started out with three questions: Does the increased chance of being caught create a larger or smaller incentive for doping in the tournament relative to the single shot game? How does a lower probability of winning in the tournament affect an athlete's doping strategy? Does greater equality in the reward scheme create a larger incentive or disincentive to doping?

Questions 1 and 2 can be addressed by comparing the equilibrium in a single game with the equilibrium in the tournament game. We can use the Finals' Round as an example of a single one shot game and compare that to the Tournament game. Continuing with the US Open parameters we get Figure 5.18.

For starters, the dark grey region to the Northeast produces pure strategy *not-doping* equilibrium in both games and the light and the light grey region to the Southwest produces pure strategy doping equilibrium in both games. The green region produces a pure strategy doping equilibrium in the single game, but in the tournament expected costs, *rc*, in this region will produce unstable equilibrium. Since there is not a pure strategy for the tournament game in this region but players have to choose either dope or *not-dope*, players will not choose to dope with certainty nor will they choose not to *not-dope* with certainty. Thus in the tournament game the green region indicates player strategies of doping with $0 < probability < 1$ and *not-doping* with $0 < probability < 1$. The blue region is a pure strategy *not-doping* region in the tournament and results in unstable player strategies in the single game, thus players will dope with $0 < probability < 1$ and *not-dope* with $0 < probability < 1$. The small yellow region in the middle is a pure strategy not-doping region in the single game but strategies are unstable in the tournament, so in the yellow region players with choose dope with $0 < probability < 1$ and choose not-dope with $0 < probability < 1$. Visual inspection tells us that, at least in the case of the US Open, the yellow region is smaller than the blue and green regions together. Therefore there is a smaller range of expected costs in which an athlete would choose PEDs in the tournament.

The green region is particularly informative for organizing bodies wishing to deter PED use in that higher fines and/or a higher probability of catching a drug user is necessary to deter PED use in competition which consists of only a single game as

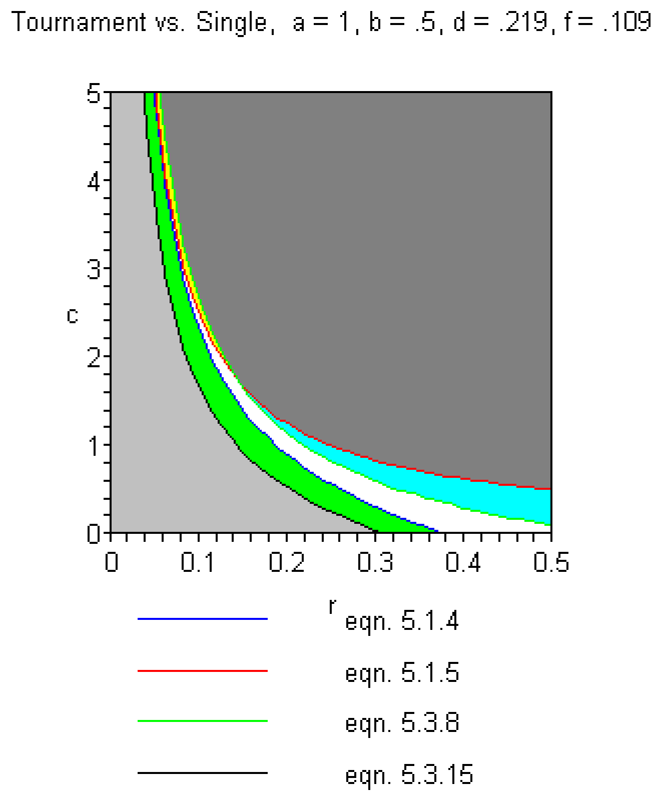

Figure 5.18: Tournament strategy regions and single game strategy regions.

opposed to competition construct along the lines of a tournament. The green region also tells us that there is more uncertainty, assuming the green region is larger than the blue region, as to whether or not an athlete will use PEDs in a tournament compared to a single game. This increased amount of uncertainty is likely due to the assumption of equally skilled players. The assumption of equal skill levels makes winning any round a matter of chance. The more rounds the tournament plays means there is more opportunity for chance to affect the outcome. An athlete could be more likely to dope in a tournament than in a single game because the chance of them losing due to some random effect is larger in the tournament, making an athlete more apt to take measures (e.g., use PEDs) to ensure their position. The assumption of equally skilled athletes could be a limiting factor in this game. Uwe Sunde notes that "rankings provide a good indicator about their opponents current shape" (Sunde, 2003, p. 18).

So what does this say about a given player's probability of choosing to use performance enhancing drugs in a tournament relative to a single game? The tournament format appears to establish a disincentive for PED use relative to the single game. In the green region an athlete will choose to use PEDs with *probability = 1* in the single game but will choose to use PEDs with $0 < probability < 1$ in the tournament. In the blue region an athlete will choose to use PEDs with probability = 0 in the tournament but will choose to use PEDs in the single game with $0 < probability < 1$. The only expected cost region where an athlete is more likely to use PEDs in the single game relative to the tournament is the yellow region where an athlete will choose PEDs with probability = 0 in the single game and $0 < probability < 1$ in the tournament.

We can answer the first two questions. The increased chance of being caught doping in the tournament creates a smaller incentive for doping in the tournament relative to the single shot game. Therefore organizing bodies wishing to deter drug use in tournaments do not need to set as high a penalty for being caught as they would if the competition were only a single game. Furthermore, a lower probability of winning in the tournament appears to deter athletes from using PEDs relative to a single game.

Figure 5.18 also points out the ineffectiveness of increasing the cost of being caught doping if the probability of being caught doping is fairly low ($r < 0.08$). It seems reasonable to assume that one of the most difficult aspects of deterring doping is actually catching the offender and the reality of the situation is such that the probability of being caught doping is fairly small. For example, in the 2004 Olympic games there were 3000 drug tests performed with 23 positives, 10 of which were weight lifters on the same team (Savalecu, Foddy & Clayton, 2004). We cannot assume that all of the 3000 athletes were using banned substances but this is only 0.8% of the athletes and this was the most ever positives in Olympic competition. Given these results and the increased possibility of a false positive with more testing focusing on the penalty could if anything exacerbate conflict between the organizing body, the athletes and the fans. The Danish doping expert Verner Møller notes that when speaking about cycling “the greatest danger to sport are the many people of good will who do not seem to understand that their helping hands have sport in a stranglehold that will eventually choke the life out of it” (Gleaves, 2010, p. 193). So what is an organizing body to do if they cannot increase the probability of being caught very much and increasing the fine for being caught, at low r, is ineffective? One possible policy measure is to decrease the inequality of the rewards for the athletes.

For an example of a more equal reward scheme we can look to auto racing. Peter von Allmen (2001) reports on the winnings of the top 30 drivers in the 1999 Winston Cup final season standings. For our purposes the top four drivers will do, where the top driver Dale Jarrett won $3,608, 829, the second place rider earned $3,550,341, third place earned $2,783,296 and fourth place, earned $2,615,226. This then establishes the parameters.

1st place = aA = A = $3,608, 829 and $a = 1$

2nd place = bA=B = $3,550,341, and $b = \frac{\$3{,}550{,}341}{\$3{,}608{,}829} = 0.98$

3rd place= dA = D= $2,783,296 and, $d = \frac{\$2{,}782{,}296}{\$3{,}608{,}829} = 0.77$

4th place = fA = F = $2,615,226 and, $f = \frac{\$2{,}615{,}226}{\$3{,}608{,}829} = 0.72$

We can then plug these values into equations (5.1.5), (5.3.8) and (5.3.15) and compare these reaction curves with the US Open values which are more unevenly distributed, Figure 5.19.

From Figure 5.19 we see that the more even payouts of NASCAR shift the reaction curves to the left which decreases the size of the doping region and increases the size of the *no-doping* region in the tournament. This is in accord with Peter von Allmen's view when discussing reward schemes in NASCAR, "If rewards are highly nonlinear, drivers have an increased incentive to exhibit reckless behavior" (von Allmen, 2001, p. 76). When a driver exhibits reckless behavior they have an increased chance of crashing which would remove the sponsor's advertisement from the race. Performance enhancing drug use is certainly a "highly risky" and "unsportsmanlike" behavior. It is for this reason that regulatory agencies are trying to deter PED use.

Following Becker (1968), Maennig (2002) models the use of banned PEDs in sports as a microeconomic model of illicit behavior. Maennig discusses a variety of policy measures in regard to deterring the use of PEDs such as externality effects and ad ministerial costs. Maennig concludes that, "An economic solution could increase the expected costs of doping by agreeing on financial penalties of a sufficiently high level" (Maenning, 2002, p. 83). The tournament game, Figure 5.18, argues that the policy of increasing the costs[14] to the athlete for being caught using PEDs will act as a deterrent only if *r* is sufficiently high already. A further argument against increasing the penalties leveled on athletes for being caught doping is the chance of a false positive. Berry (2008) notes that given the present state of the drug testing procedures in the Tour de France there is between an 8% and 34% chance of a false positive. As such a Tour de France bike racer has between an 8% and 34% chance of being 'caught' doping even if

[14] The *Drug Free Sports Act* of the 109th Congress is a proposal for a bill which would have "established a Federal drug-testing policy, using the standards set by the Olympic Committee, for the National Football League, the National Basketball Association, the National Hockey League, Major League Baseball, Major League Soccer, and the Arena Football League. The bill would have required a 2-year ban for the first offense and a lifetime ban for the second and would have mandated two tests per athlete each year. The other steroids related bill, the Clean Sports Act of 2005, sponsored by representatives Thomas M. Davis III (R-VA) and Henry A. Waxman (D-CA), would have imposed the same penalties but would have required five tests per athlete each year." *Office of Legislative Policy and Analysis*, http://olpa.od.nih.gov/legislation/109/pendinglegislation/drugsports.asp

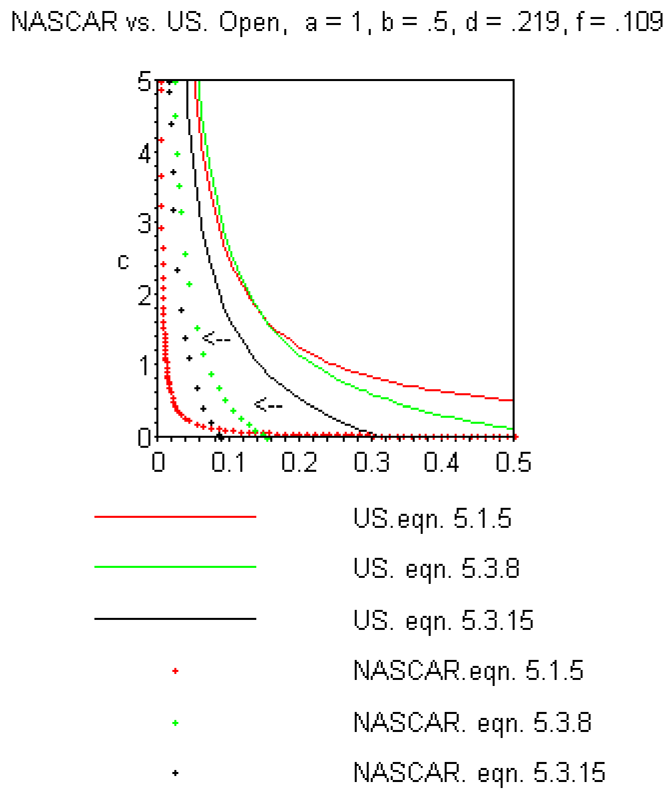

Figure 5.19: NASCAR reward scheme and US Open reward scheme.

they are not doping. Not only is increasing the cost of doping ineffective with low *r*, but high fines punish innocent athletes even more as the result of false positives. A more even reward scheme in tournaments could go a long way in alleviating both of these issues of unfairness. The more even reward scheme shifts the doping pure strategy region to the left (Figure 5.19), making lower monetary penalties for doping more effective at low *r* and the lower monetary penalties reduce some of the unfairly imposed costs to athletes who are victims of false positives.

The multistage tournament game argues that in rank order tournaments a more equal distribution of skill levels of the athletes could play a role in an athlete's strategy to use PEDs. Organizing bodies do not wish to reduce uncertainty of outcome so regulating the incentive to cheat through controlling the events on the court or field is not a good way to go. As far as I am aware this has not been a strategy used to deter PED use. The focus on increasing the probability of being caught and increasing the penalties associated with being caught has been a strategy used to deter doping. The multistage tournament game suggests the alternative strategy of distributing the value of the prizes more equally as a more fair and effective policy.

CHAPTER 6

CONCLUSION

Chapter 3 addressed the issue of the return to investing in four types of players, amateur free agents, drafted players, international free agents and unrestricted free agents. Amateur free agents and drafted players produce the largest returns to investment, with amateur free agents in their first 3 years of service producing the largest returns overall, producing a 446% return to investment in salary over the first 3 years of MLB service. International free agents over the first 6 years of their MLB service and unrestricted free agents, on the other hand, are producing negative returns to investment. These results are consistent with a “winners curse” in the market for unrestricted free agents and International free agents. The results of this chapter provide a blue print for how a profit maximizing team should go about building a profitable team by building a team through the draft, particularly pitchers, and through the amateur free agent market for position players. The profitability of the amateur free agent market in conjunction with the sky rocketing salaries and the “winners curse” of the unrestricted free agent market could explain the recent rise in the numbers of Dominican and Venezuelan players in MLB.

In regard to fairness, the policy, suggested by the Blue Ribbon Panel Report, of implementing an international reverse order draft would go to some lengths in reducing the exploitation of amateur free agents coming from Latin America and the Caribbean.

The monopsonistic policy of the reserve clause does its part to exploit players over the first 6 years of their contracts whereby players receive $0.51 on average for every dollar they produce for the team. The exploitation is worse over the first 3 years when players only receive $0.23 for every dollar in MRP they produce, but the exploitation is even worse for the amateur free agent who receives $0.18 on average for every dollar produced. An international player draft could reduce some of this exploitation, transferring about $0.05 in MRP back to the amateur free agent. Since most of these amateur free agents come from the Dominican Republic and Venezuela and both of these countries already have a fairly well established development league, a reverse order draft applied only to these countries could go toward reducing the level of exploitation these players are hit with when they come to play in MLB.

Chapter 4 addressed the equal distribution of end of season point totals in the National Hockey League, the Russian Elite League and the Czech Republic League. In all three of these leagues end of season point totals are becoming more unequally distributed and thus the certainty of the outcome of any game is becoming more certain over time. In the NHL, the 1999/00 to 2003/04 seasons showed the lowest level of average league parity, which corresponds to scoring system 2 where one point was awarded for an overtime loss and 1 point for an overtime tie. This scoring system was subsequently discontinued after the strike season of the 2004/05 season to scoring system 3 where a shootout decided the victor in the case of a tie game at the end of overtime. Scoring system 3 improved league parity bringing it more in line with the years prior to 1999.

The effect the size of the labor market has on this distribution was tested with the results being that when talent becomes more decompressed (i.e., fewer players chasing more roster spots), the distribution of end of season point totals is more unequally distributed. Two cases of talent decompression and one case of talent compression were tested. Talent decompression, as was seen with the rival hockey league, in the WHA does correspond with a period of a more unequal distribution of end of season point totals. As concerns talent compression there does not seem to be a significant relationship between talent decompression and lower inequality.

A causal relationship between talent compression/decompression and the distribution of end of season point totals turns up insignificant results. Even though players were emigrating out of the Czech Republic and Russia to play in the NHL and the distribution of end of season point totals was becoming more unequal it wasn't the change in the size of the talent pool that was driving this phenomenon. Furthermore the increase in the size of the talent pool in the NHL was not driving the distribution of end of season point totals. It appears that in the case of professional hockey, the increased opportunities open to Russian and Czech players after the fall of the Berlin Wall has done little to reduce the unequal distribution of end of season point totals in the NHL, REL or CRL.

Chapter 5 addressed the issue of fair and effective punishment for the violating the league policy of banned performance enhancing drug use. A multistage tournament game was used to determine if an athlete would more likely engage in using performance enhancing drugs to obtain an unfair advantage in a tournament relative to a single one off match. Using the 2009 US Open prize structure, it is shown that a higher expected cost is required to deter PED use in a single game relative to a multistage tournament. A sport organizing body wishing to deter PED use would need to establish a higher expected cost if the competition were a single game. The results also argue that if the probability of being caught is fairly small then increasing the costs to doping are ineffective in deterring doping in either a multistage tournament or a single game. This result argues that the policy of increasing the fine for being caught will not act to deter doping unless the science of catching dopers can increase the probability of being caught to a high enough level. For example, if the probability of being caught doping were increased from 0.1 to 0.14 a no doping Nash equilibrium could be obtained with a fine that is twice as large as the prize for winning but if the probability of being caught doping were to stay at 0.1 then the fine would have to be three times the reward for winning. Given that there is a positive probability[1] of a false positive in any testing procedure increasing fines at low probability of being caught could be viewed as an unfair policy which in effect increases the punishment to innocent athletes and does little to prevent athletes from using PEDs. Furthermore, if a sport organizing body wishes to increase the probability of being caught by increasing the number of tests as opposed to the accuracy of the tests they will also work to increase the number of false positives.

Most sporting events can be viewed as tournaments and not single games. Even sports such as football, which play a single game once a week for 16 weeks, can be modeled as a tournament where the season is seen as the qualifying rounds and the playoffs are the finals. The results demonstrated in Chapter 5 would suggest that the

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[1] Berry (2008) estimates between an 8 and 34% chance of a false positive in the Tour de France bike race. See Chapter 5 Section 5.8.

policy of increasing the fines for doping in all sports is at best an ineffective policy and at worst, due to false positives, an ineffective and unfair policy.

Chapter 5 also looked at the structure of the reward scheme in the tournament to determine if a more or less equal reward scheme could be used to deter PED use among athletes. It is shown that a more highly nonlinear reward scheme creates a larger incentive relative to a more linear reward scheme, for athletes to use PEDs. This would suggest that increasing the equality of the prizes would act to deter drug use on its own as long as there were a probability > 0 of being caught and fine > 0 for being caught.

Taking these two issues into account, the ineffectiveness of high fines at low probability of being caught and the deterrence effects of more equal prizes, an effective drug deterrent policy would focus on more equal prizes and not on increasing the punishment for being caught. A policy of this sort would be both more effective and fair with a more equal reward scheme and a lower probability of punishing an innocent athlete through increasing the likelihood of a false positive.

This research project began with a discussion of John Rawls' just social contract. Noting that "nature deals out attributes and social positions in a random or accidental way" (Rawls, 1971, p. 15). It was then discussed that league policy, as in the reverse order draft are directed at creating a just league by guiding the manner through which player attributes, in this case player talent, are distributed. It turns out that the draft does not provide teams with more ability to exploit players rather the contrary seems to hold amateur free agents are exploited more than are drafted players. It was then hypothesized that nature itself, in the sense of more high talent players chasing fewer roster spots could work toward increasing league parity. In this case it seems that nature does not appear to be working for or against league parity. Finally, the level of fairness was brought down to the court of play, where the use of performance enhancing drugs is seen as providing an unfair advantage to one athlete. A fair league wishing to deter this unfair advantage would be better served by equalizing the prizes and not increasing the fine for doping.

6.1 Future Research

This dissertation has answered some questions and brought up some more questions for future research. A further extension would be to see if small market teams are being disproportionately harmed by the free agent winners curse and to see if teams who have been in the Dominican Republic longer have become more efficient in regard to their salaries for Dominican players. The relationship between economic efficiency and winning could also be addressed. Are the more economically efficient St. Louis Cardinals also more likely to win? One could also look at why players who change teams in the first 3 years increase their salary, but if they change in years 4, 5 or 6 their salary decreases.

In regard to the draft one could look to the competitive balance implications of an international reverse order draft using the implementation of a reverse order draft for Canadian and Puerto Rican baseball in 1990. In addition, since the NHL includes international players in their reverse order draft one could compare competitive balance in the NHL with that in MLB. It could also be interesting to use the methodology in Chapter 3 to assess what the return to investment for international hockey players is and compare the degree of exploitation or positive return to investment for incoming international hockey players relative to incoming MLB players. Finally the dataset on player birth places could be used to look at the relationship between attendance and the number of international players on a given team.

In regard to competitive balance, the National Basketball Association (NBA) has recently been compared to the English Premier League in regard to the concentration of talented players on fewer teams. The adjusted R measure which takes into account tie games could be used to compare competitive balance in the NBA and the EPL. A similar analysis of the decompressing effects on the NFL of the rival AFL and USFL could provide more information as to the role of talent supply and competitive balance.

The Performance Enhancing Drug game could be extended to the inclusion of false positives. How does including the possibility of a false positive change the doping strategy? One would intuitively expect that if an athlete thought they might be punished even if they chose not to use PEDs then they would be more likely to use PEDs since they might think what do I have to lose? It should also be addressed in this research that when the probability of being caught is increased through a greater number of tests, then the probability of a false positive also increases.

APPENDIX A

THE ROLE OF CONJECTURES IN MODELS OF PROFESSIONAL SPORTS LEAGUES

In the sports league models conjectures become relevant in the calculation of the marginal product of talent. In a two team league the winning percent of team 1 is a function of the talent of team 1 and the talent of team 2. We can express this as: $w_1 = w_1(t_1,t_2)$ and $w_2 = w_2(t_1,t_2)$. The zero sum nature of sports or the adding up constraint requires that $w_2 = 1 - w_1$. A change in winning percent is the marginal product of talent (MPT). MPT is the derivative of the winning function in terms of own team talent. In other words, the owner is asking herself, how much will my teams winning percent change with a change in an increment of talent. This decision for the owner of team 1 can be modeled as (1).

(1) $$w_1 = \frac{dw_1(t_1, t_2)}{dt_1}$$

Talent is a notoriously elusive characteristic to model due to the fact that it is difficult to observe. For this reason sports economists[1] have used 'contest success function's' (CSF's) to relate unobserved talent to observed winning percentage. The most common form is the logistic form.

(2) $$w_i = \frac{t_i^{\gamma}}{[t_i^{\gamma} + t_j^{\gamma}]}$$

[1] Of note are: El Hodiri and Quirk (1971), Fort and Quirk (1995), Vrooman (1995), Rascher (1997), Syzmanski (2003, 2004), Syzmanski and Kesenne (2004) and Kesenne (2006, 2007).

In order to determine the marginal product of talent for team 1 (in what follows determining for one team will suffice) one simply applies (1) to (2), yielding (3).

$$\frac{dw_1}{dt_1} = \frac{t_2^{\gamma} - t_1^{\gamma}\dfrac{dt_2^{\lambda}}{dt_1}}{[t_1^{\gamma} + t_2^{\gamma}]^2} \tag{3}$$

"The parameter γ determines the "power," or degree of impact, of talent choice on winning percent. Low values of γ mean that differences in talent between teams have little impact on winning" (Fort & Winfree, 2007, p. 4). For simplicity assume $\gamma = 1$ for the moment. Yielding (3a).

$$\frac{dw_1}{dt_1} = \frac{t_2 - t_1\dfrac{dt_2}{dt_1}}{[t_1 + t_2]^2} \tag{3a}$$

Equation 3a shows that the incremental change in winning percent of team 1 depends on how team 2's talent changes when team 1 chooses to change its own talent. The value of the derivative $\frac{dw_1}{dt_1}$ depends on how team 2 will react to team 1's talent decision (i.e., $\frac{dt_2}{dt_1}$). The value of $\frac{dt_2}{dt_1}$ is where the conjecture comes into play.

El-Hodiri and Quirk (1971), Fort and Quirk (1995), Vrooman (1995) and Quirk and Fort (1997) assume that the talent supply is fixed (i.e., $\frac{dt_2}{dt_1} = -1$) so that if one team acquires a player and receives a talent gain then that gain is equivalent to a lose of the other team. As noted above this result in a conclusion consistent with the invariance principal in that revenue sharing will have no effect on competitive balance. Syzmanski and Kessene (2004) and Syzmanski (2004) allow for a flexible talent supply such that one team's talent decision has no effect on the other team's winning percent. The flexible talent supply model conjectures that $\frac{dt_2}{dt_1} = 0$. The result is that revenue sharing has a negative impact on competitive balance.

APPENDIX B

SELECTED DATA SOURCES

For Chapter 3, team and player performance statistics, birth countries, high school or college attended and salaries from the Lahman Baseball Database at www.baseball1.com. Total revenue data were from Rodney Fort at www.rodneyfort.com which for the years prior to 2001 come from Financial World Magazine and after 2001 from Forbes Magazine.

For Chapter 4 end of season point totals for the Russian Elite League and the Czech Republic League are from The Internet Hockey Database at www.hockeydb.com. End of season point totals for the NHL are from SHRP sports at www.SHRPsports.com and player birthplaces are from Databasehockey.com at www.databasehockey.com.

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